Wildfire Exceptional Events Demonstration for Ground-Level Ozone in the Chicago 2008 Ozone Nonattainment Area

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Prepared by:

Alpine Geophysics, LLC
387 Pollard Mine Road
Burnsville, NC 28714

For

Illinois Environmental Protection Agency

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Introduction

The following is Illinois' Exceptional Event Demonstration, which clearly establishes that plumes from Arizona wildfires adversely affected ozone data in a regulatorily significant way at the Northbrook Water Plant ozone monitor in Northbrook, Cook County, Illinois. Wildfires occurred across Arizona throughout June 2020. Table 1 identifies the Illinois monitor that was affected by smoke transported from Arizona wildfires from June 18-19, 2020, such that the data should be excluded from regulatory determinations.

Table 1. Data Requested for Exclusion

Parameter	Area	Monitor ID	Site Name	County	Dates
Ozone	Chicago	170314201	Northbrook Water Plant	Cook	June 18 and 19, 2020

40 CFR 50.14 establishes the procedures for submitting an Exceptional Event Demonstration. Specifically, 40 CFR 50.14(c)(3)(iv) states: "The demonstration to justify data exclusion must include:

A. A narrative conceptual model that describes the event(s) causing the exceedance or violation and a discussion of how emissions from the event(s) led to the exceedance or violation at the affected monitor(s);
B. A demonstration that the event affected air quality in such a way that there exists a clear causal relationship between the specific event and the monitored exceedance or violation;
C. Analyses comparing the claimed event-influenced concentration(s) to concentrations at the same monitoring site at other times to support the requirement at paragraph (c)(3)(iv)(B) of this section. The Administrator shall not require a State to prove a specific percentile point in the distribution of data;
D. A demonstration that the event was both not reasonably controllable and not reasonably preventable; and
E. A demonstration that the event was a human activity that is unlikely to recur at a particular location or was a natural event."

The following demonstration was prepared in accordance with 40 CFR 50.14, U.S. Environmental Protection Agency's (EPA) September 16, 2016, "Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations"[1] (herein referred to as Exceptional Events Guidance), and U.S. EPA's "EPA Review Technical Support Document Template for Wildfire/Ozone Events."[2]

[1] https://www.epa.gov/sites/production/files/2016-09/documents/exceptional_events_guidance_9-16-16_final.pdf
[2] https://www.epa.gov/sites/production/files/2017-06/documents/tsd_template_ozone_wildfire_ee_2017_0606.pdf

Summary of Findings

This report:

1. Contains the required narrative conceptual model describing the Arizona wildfire events that caused the violation at the Northbrook ozone monitor, and how emissions from those events reached the affected monitor, leading to elevated measured ozone concentrations on the specific days in question.
2. Demonstrates that there was a clear causal relationship between the smoke and the maximum daily average 8-hour (MDA8) ozone exceedances.
3. Contains analyses comparing the ozone concentrations during the event-influenced days to concentrations at the same monitor at other times on days with similar meteorological conditions.
4. Demonstrates that the wildfires causing smoke were not reasonably controllable or preventable and are unlikely to recur, and that they were considered natural events.

Key findings and evidence supporting these assertions include the following:

1. Considerable ozone was created upstream of Illinois due to the presence of wildfire smoke generated during one of Arizona's largest recorded wildfire years, which was then transported into Illinois over several days.
2. Meteorological conditions (at the surface and aloft) were favorable for transport of smoke from the southwestern U.S. into the Lake Michigan region, including Illinois.
3. Ozone concentrations on June 18 and 19, 2020, at the Northbrook monitor were above the 99th percentile of the 5-year distribution of ozone monitoring data at the site and were both in the four highest ozone concentrations within the year and were the 9th and 11th highest observations in the past 5-year period.
4. Satellite images captured visual smoke plumes that were transported into the Lake Michigan region on days when the ozone concentrations were highest.
5. Analysis of the National Oceanic and Atmospheric Administration's (NOAA) Hazard Mapping System (HMS) smoke product and Ozone Air Quality Index (AQI) shows an enhanced ozone concentration impact at monitors along the wildfire smoke transport path that eventually culminates with excess ozone observations in Chicago.
6. Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) retrievals identified smoke among the classified aerosols at the surface in the region during the June 18 and 19, 2020, episode.
7. Regional upwind measurements identify multiple monitors with unusually high ozone concentrations during the dates when the transported smoke plume passes through the region.
8. Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model forward and backward trajectory analyses demonstrate that the wildfire smoke was transported into the Lake Michigan region and was then transported into the Chicago area.
9. Additional satellite retrievals demonstrate the transport of wildfire smoke into the Lake Michigan region and provide additional evidence that the smoke plume and associated ozone precursor emissions were present during the June 18 and 19, 2020, episode.
10. Fine particulate matter (PM2.5), carbon monoxide (CO), and nitrogen oxides (NOx) were elevated during the event, consistent with a wildfire smoke plume.
11. PM2.5 speciated data (organic carbon and potassium ion) showed elevated wildfire attributable concentrations.

12. Similar day analysis showed similar days in previous years did not yield as much ozone.
13. A screening analysis of average standardized log-transformed timeseries concentrations of key pollutants provides supporting evidence for smoke influence in the Chicago region during the June 18-19, 2020, episode.
14. A Q/d analysis, while not meeting specific U.S. EPA thresholds for clear causal influence, is consistent with other previous long-range smoke and ozone transport events approved by U.S. EPA.

Several analytical methods were used to develop a weight of evidence demonstration that the 8-hour ozone concentrations above 75 parts per billion (ppb) in the June 2018 event meet the rules for data exclusion as an Exceptional Event. In summary, satellite images and data, meteorological data, trajectory analysis, screening tools, and speciated PM2.5 data were used to assess whether conditions were favorable for transport of smoke from the Arizona wildfires to monitors that showed 8-hour ozone concentrations above 75 ppb. The data also showed that the transported smoke degraded air quality upstream of Chicago first, then this photochemically aging airmass was transported northeastward, creating a prolonged period (June 17-20, 2020) of enhanced ozone from the Mississippi River into the Lake Michigan region, including Illinois.

Illinois' analysis strongly supports that the Northbrook monitor was impacted by smoke, that concentrations on June 18 and 19, 2020, meet the rules as an Exceptional Event, and that the Northbrook monitor and associated ozone observations on these days should be excluded from design value calculations.

Exceptional Event Demonstration

A. Regulatory Significance

The Exceptional Events rule applies to data showing an exceedance of a standard which may affect regulatory determinations regarding attainment designation status or other actions by the Administrator.

Exclusion of the June 18 and 19, 2020, data may allow the Chicago-Naperville, IL-IN-WI 2008 ozone nonattainment area (Chicago NAA) to be eligible for redesignation to attainment for the 2008 ozone National Ambient Air Quality Standard (NAAQS). Table 2 compares preliminary 2018-2020 design values calculated with and without the inclusion of data from the event. The 2020 design value data are preliminary and based on data reported through November 15, 2020, which have not yet been certified. Exclusion of the June 18 and 19, 2020, ozone data would reduce the preliminary 2018-2020 design value for the nonattainment area (NAA) controlling monitor at Northbrook Water Plant (17-031-4201) from 77 ppb (nonattainment) to 75 ppb (attainment) thereby bringing the entire Chicago NAA into attainment with the 2008 ozone NAAQS.

Table 2. 2018-2020 (Preliminary) Design Values With and Without June 18 and 19, 2020, Data

Parameter	Area	Monitor ID	Site Name	County	Maximum 8-hr Avg Ozone (ppb)		2018-2020 Design Value (ppb)	
					6/18/20	6/19/20	Current	Excluding Data
Ozone	Chicago	17-031-4201	Northbrook Water Plant	Cook	80	82	77	75

Depending on 2021 and 2022 data, exclusion of the June 18 and 19, 2020, data may have regulatory significance for other actions by the Administrator, including future clean data determinations, redesignations, violations of the 2008 ozone standard, triggers of contingency measures under the 2008 ozone NAAQS, or violations of the 2015 ozone NAAQS.

B. Narrative Conceptual Model

Area Description

As shown in Figure 1, the Chicago-Naperville, IL-IN-WI 2008 ozone NAA is defined as Cook, DuPage, Kane, Lake, McHenry, Will, and partial portions of Grundy and Kendall Counties in Illinois, Lake and Porter Counties in northwest Indiana, and a portion of Kenosha County, Wisconsin.

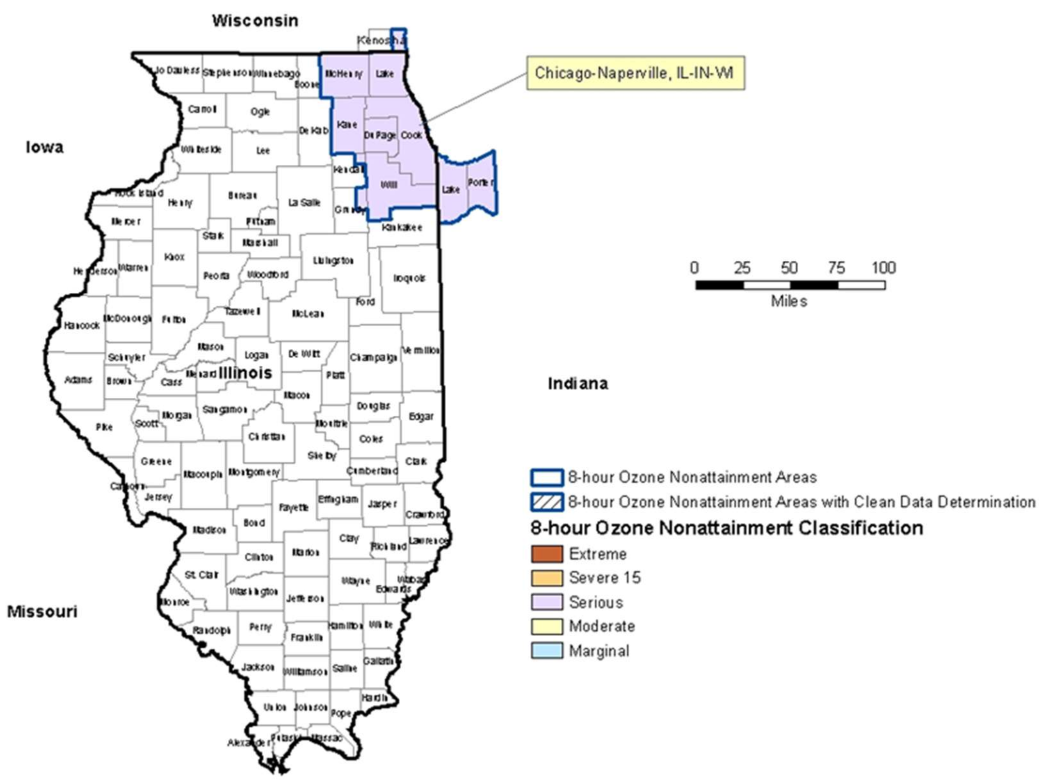

Figure 1. Illinois 8-hour Ozone Nonattainment Area (2008 NAAQS).

On June 11, 2012, U.S. EPA designated the Chicago metropolitan area, including all or portions of eight counties in Illinois, two counties in northwest Indiana (Lake and Porter), and one partial county in southeast Wisconsin (Kenosha) as a “marginal” ozone NAA based on monitoring data from 2009-2011. The attainment deadline for marginal NAAs to meet the 2008 ozone NAAQS was July 20, 2015.

On April 11, 2016, U.S. EPA determined that the Chicago metropolitan area failed to attain the 2008 ozone NAAQS by the applicable attainment date and thus reclassified the area as a “moderate” ozone NAA. The attainment deadline for moderate NAAs to meet the 2008 ozone NAAQS was July 20, 2018.

On August 23, 2019, U.S. EPA determined that the Chicago metropolitan area again failed to attain the NAAQS and thus reclassified the area as a “serious” ozone NAA.

As a result of the actions for the Chicago NAA described above, the states of Illinois, Indiana, and Wisconsin must submit State Implementation Plans (SIPs) that meet the requirements applicable to “serious” ozone NAAs. The NAA SIPs, or attainment demonstrations, must include a demonstration which identifies emissions reduction strategies sufficient to achieve the NAAQS by July 20, 2021, which is the attainment date for serious NAAs. Because the attainment deadline occurs during the 2021 ozone season, the effective attainment deadline is the end of the 2020 ozone season.

Ozone has significantly decreased in the Chicago NAA due to sizeable and sustained reductions in ozone precursor emissions. This is evident in Figure 2 below, showing the number of days in each year since 2000 exceeding the 75 ppb NAAQS for ozone.

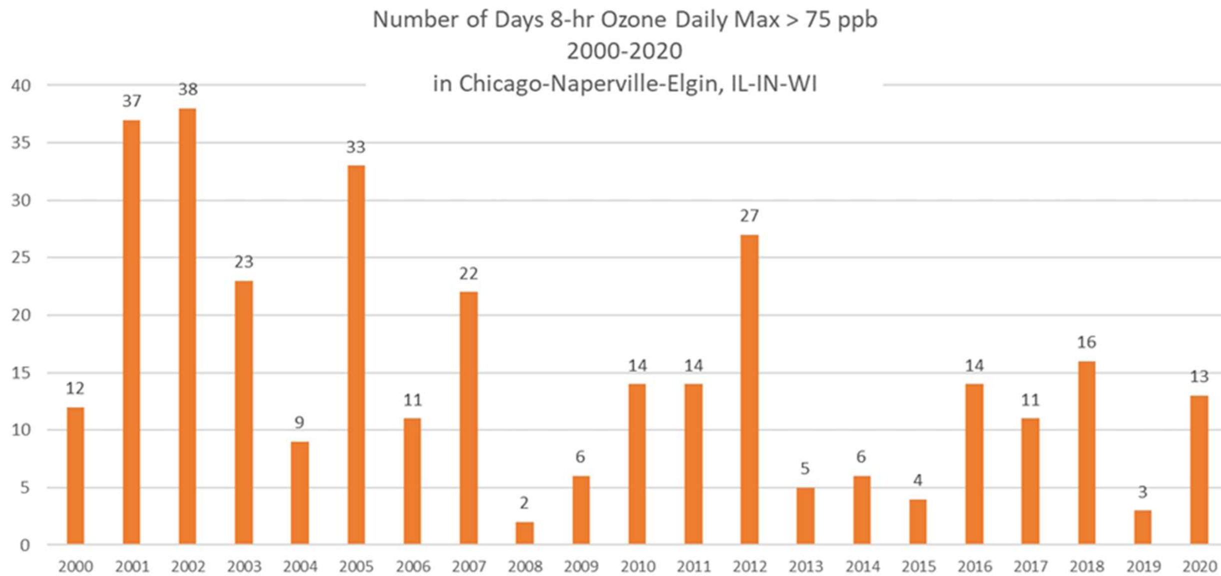

Figure 2. Number of Days Exceeding 2008 Ozone NAAQS Level of 75 ppb

The Northbrook Water Plant site (Cook County; Monitor ID 17-031-4201; Lat +42.13999619, Lon -87.79922692) is an urban scale site located in a residential/industrial area in the Northbrook suburb of Chicago. Located at the northern edge of Cook County, Illinois, this is a Photochemical Assessment Monitoring Stations (PAMS)/National Core (NCORE) station located at 750 Dundee Road, 1 km southwest of the Chicago Botanic Garden and 3.75 km west of Lake Michigan.

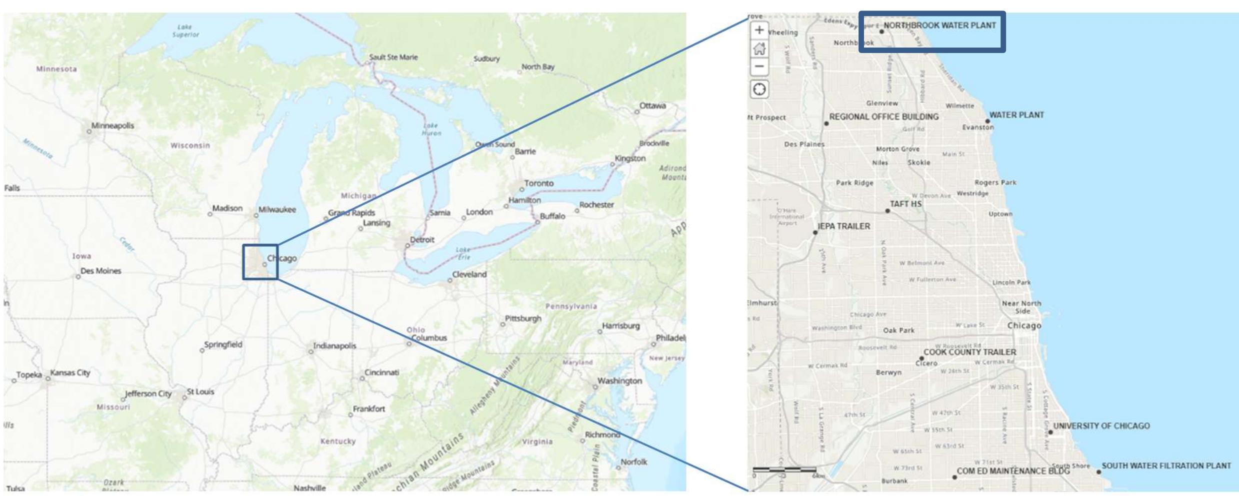

Figure 3. Chicago Area Northbrook Water Plant Monitor Requested for Data Exclusion.

Characteristics of Non-Exceptional Event (Typical) Ozone Formation

The following conceptual model of typical ozone formation characteristics is adopted from Lake Michigan Air Directors Consortium's (LADCO) November 19, 2020, "Attainment Demonstration Modeling for the 2008 Ozone National Ambient Air Quality Standard Technical Support Document."[3] This regional description is applicable to the Chicago area.

Based on the data and analyses presented in the LADCO report and previous conceptual models and technical support documents developed for the Lake Michigan region, a conceptual model of the behavior, meteorological influences, and causes of high ozone in the Chicago NAA is summarized below:

- Monitoring data show that, as of 2019, all surface ozone monitoring sites in the western Lake Michigan region were meeting the 2008 8-hour ozone NAAQS. Historical ozone data show a downward trend over the past 19 years, due likely to federal and state emission control programs. Concentrations declined sharply from 2002 through 2010, and again from 2012 through 2015. There were no 3-year design values in violation of the 2008 ozone NAAQS at any monitor in the region in 2019.
- Ozone concentrations are strongly influenced by meteorological conditions, with high ozone days and higher ozone levels occurring more frequently during summers with above-normal temperatures. Nevertheless, meteorologically-adjusted trends at the controlling monitors show that concentrations have declined, even on hot days, which provides strong evidence that emission reductions of ozone precursors have been effective.
- The presence of Lake Michigan influences the formation, transport, and duration of elevated ozone concentrations along its shoreline. Depending on large-scale synoptic winds and local-scale lake breezes, different parts of the area experience high ozone concentrations. For example, under southerly flow, high surface ozone concentrations can occur in eastern Wisconsin, and under southwesterly flow, high surface ozone can occur in western Michigan.
- A natural lake-land breeze circulation pattern is a major cause of the high ozone concentrations observed along the lakeshore. This pattern is driven by surface temperature gradients between the lake and the land. At night and during the early morning hours, when the lake surface is warmer than the land surface, a land breeze forms (surface winds travel from the land to the lake). The land breeze transports ozone precursors from industrial and mobile sources on land to the area over the lake. When the sun rises, the ozone precursors over the lake begin to rapidly react to form ozone. The lake breeze transports the ozone precursors and the concentrated ozone that has formed above the lake surface and precursors from the lake, inland to a narrow band along the lake shore. The ozone concentrations observed along the lakeshore that violate the NAAQS are often associated with lake-land breeze patterns.
- Areas in closer proximity to the lake shoreline display the most frequent and most elevated ozone concentrations.

[3] https://www.ladco.org/wp-content/uploads/Documents/Reports/TSDs/O3/LADCO_2008O3_SeriousNAASIP_TSD_19Nov2020.pdf

Wildfire Description

The Arizona 2020 wildfire season has burned just under 955,000 acres as of mid-November 2020, according to the Arizona Department of Forestry and Fire Management[4]. That value is almost double the 520,000 acres that burned in 3,627 fires over the previous *two* years combined (approximately 165,000 acres in 2018 and 385,000 acres in 2019)[5]. Figure 4 presents 2020 wildfires in Arizona with fires larger than 1,000 acres labeled individually. The Bush, Bighorn, and Mangum wildfires are circled.

Fire and smoke maps show large plumes of wildfire smoke emanating from a southwest Arizona wildfire complex burning June 5 – July 6, 2020. During June 11-15, 2020, this smoke was initially transported in an easterly flow across much of the southeastern United States. Then residual smoke and newly generated wildfire smoke were both transported to the Lake Michigan region during a period that included June 18-19, 2020. Three wildfires of note from this complex, the Mangum, Bush, and Bighorn wildfires, were among the largest in Arizona wildfire history with the Bush fire listed as the fifth-largest recorded in the state.

The Bush, Mangum, and Bighorn fires occurred following an unusually hot dry spring season. In April 2020, the Arizona Department of Forestry and Fire Management expected a "potentially active" fire season reminiscent of the 2019 season. Increased grass load from a wet winter was expected to contribute to an elevated risk of fire in the central Arizona deserts. Southwest Coordination Center Predictive Services forecasted an Above Normal risk for significant wildland fires from May through July for most of Arizona. They cited above-normal fine fuel loading in southern Arizona deserts and an active weather pattern through mid-June to support this risk.

[4] https://dffm.az.gov/

[5] National Interagency Coordination Center and the National Fire and Aviation Management Web Applications

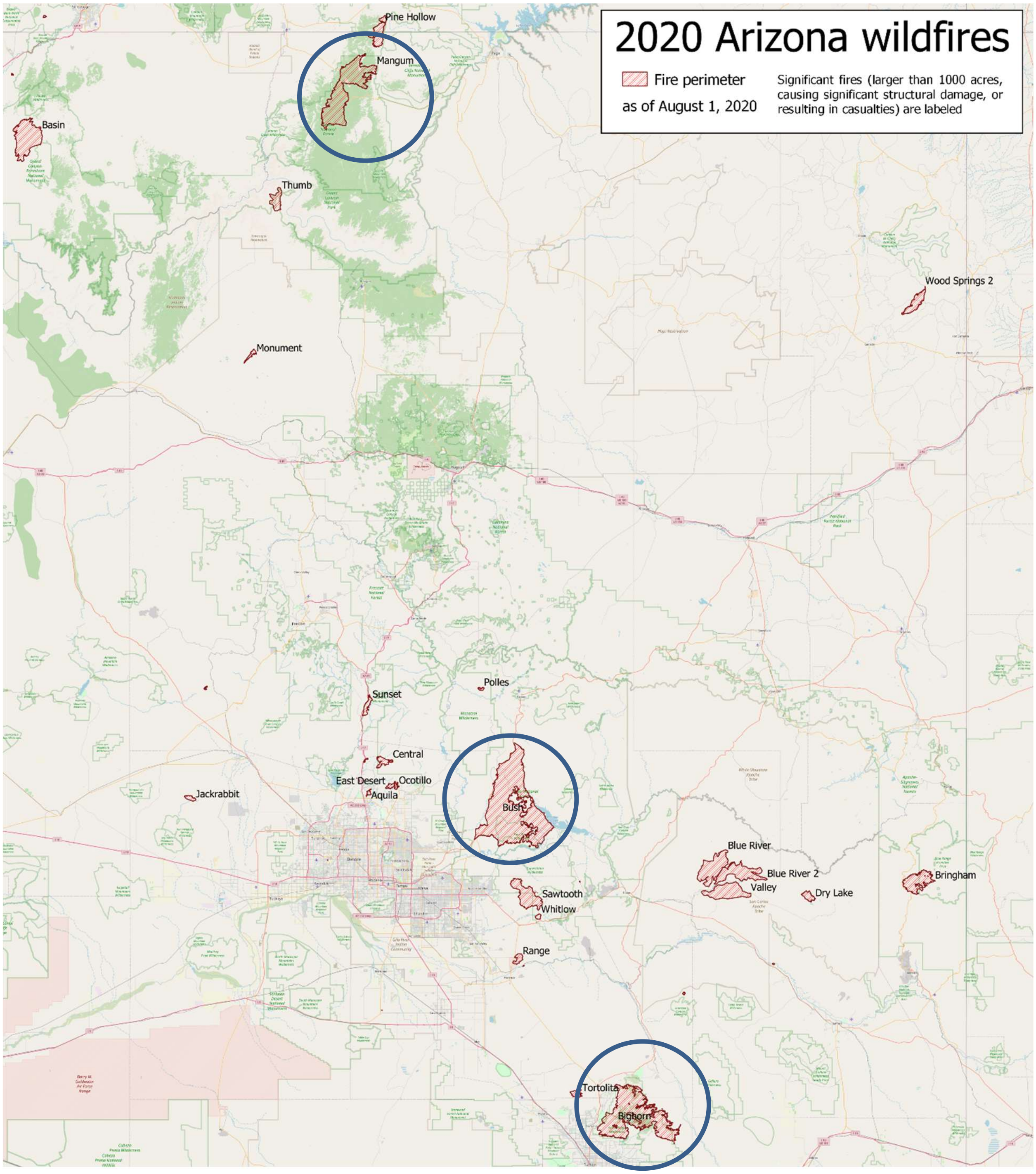

Figure 4. Perimeters of fires in the state of Arizona during 2020[6]. Fires larger than 1000 acres or otherwise significant are labeled. Mangum (top), Bush (middle), and Bighorn (bottom) wildfires are circled.

[6] Map data (c) OpenStreetMap (and) contributors, CC-BY-SA, Atomic7732.

The Bush Fire[7] was a human-caused wildfire that started in the Tonto National Forest northeast of Phoenix, Arizona. It burned 193,455 acres. The fire started on June 13, 2020, near the intersection of Bush Highway and SR 87 and was not fully contained until July 6, 2020.

Figure 5. Bush Fire in the Mazatzal Mountains as seen from Fort McDowell, AZ, on June 16, 2020[8].

[7] https://inciweb.nwcg.gov/incident/6773/

[8] CC BY-SA 4.0; Atomic7732

The Bighorn Fire[9] was a wildfire in the Santa Catalina Mountains north of Tucson, Arizona on the Coronado National Forest. It burned 119,987 acres until it was finally put out on July 23, 2020. A lightning strike from a storm on the evening of June 5, 2020, caused the fire.

Figure 6. The Bighorn Fire on the slopes of the Catalina Mountains as seen on June 12, 2020[10].

[9] https://inciweb.nwcg.gov/incident/6741/

[10] Kelly Presnell/Arizona Daily Star via AP

The Mangum Fire[11] was a wildfire that burned in Kaibab National Forest in Arizona. The fire, which started on June 8, 2020, was approximately 16 miles north of the North Rim of Grand Canyon National Park and burned a total of 71,450 acres. It was not fully contained until July 27, 2020. The exact cause of the fire remains under investigation; however, fire officials have confirmed it was human caused.

Figure 7. Smoke from the Mangum Fire as seen on June 12, 2020[12].

[11] https://inciweb.nwcg.gov/incident/6748/

[12] https://inciweb.nwcg.gov/incident/photographs/6748/24/

This news article describing the Bush, Bighorn, and Mangum fires provides additional information about the scale and impact:

Arizona reels as three of the biggest wildfires in its history ravage state – The Guardian, 2 July 2020[13]

> *"But on 5 June lightning ignited a wildfire that has grown to engulf over 118,000 acres. The fires are still only 58% contained. Called the Bighorn fire, it is the eighth-biggest in state history, and it has transformed the Catalinas into a hub for the study of the impacts of climate change. Nasa satellite photos show large scar marks left by the fire.*
>
> *At night you can see basically the outline of the fire on the mountain," said Courtney Slanaker, the executive director for the American Red Cross Southern Arizona, "and then during the daytime you're seeing that heavy smoke as it moves through different fuel sources on the mountain.*
>
> *And yet, Bighorn is just one of three fires that sit in the top 10 biggest wildfires in Arizona history.*
>
> *The Bush fire in the Tonto national forest, about 30 miles from Phoenix, now covers 193,000 acres and 98% is contained. It is the fifth-biggest in state history. Meanwhile, the Mangum fire burning in the Kaibab national forest now covers over 71,000 acres and 67% contained. The trio of fires are bigger than Washington DC, San Francisco, Baltimore, Chicago, Miami, Minneapolis and Manhattan combined."*

[13] https://www.theguardian.com/environment/2020/jul/02/arizona-wildfires

Conceptual Model of Ozone Formation and Transport from Wildfires

Wildfire smoke plumes contain gases including non-methane hydrocarbons (NMHCs), CO, NOx, and aerosols, which are all important precursors to photochemical production of tropospheric ozone and can travel thousands of kilometers. Smoke plume transport may cause urban areas far downwind of the fires to see greater enrichment of ozone compared to areas closer to the wildfires. Upper-level winds at the Northbrook monitor during the June 18-19, 2020 event originated from a south-southwestern direction, bringing with it smoke plumes attributed to multiple Arizona wildfire complexes.

Many variables, such as type of fuel or forest burned, plume path, and acreage burned, affect the intensity of the fire and ability of a plume to enhance downwind ozone production. High elevation desert coniferous forests, like those associated with Arizona wildfires, sustain high levels of invasive annual grasses whose abundance and continuity of fine fuels have been increasing with recent warmer, drier weather patterns and result in more frequent and larger fires.[14] Structurally, these woodlands (pinyon–juniper) are rather simple, characterized by being an open forest dominated by low, bushy, evergreen junipers[15].

The impact of wildfires on regional-scale atmospheric chemistry depends on the physical and chemical transformations that take place as fire emissions are transported, diluted, and exposed to chemical oxidants. Ozone and other oxidants can be formed along the way, and particle mass-loadings can grow or shrink[16]. Not all the factors that regulate these processes are well understood and individual fire plumes can have different behaviors.

The reasons for these complexities may have to do with how fast the plume was lofted and cooled or how efficiently NOx was converted to products such as peroxyacetyl nitrate (PAN). When mixed with urban emissions[17], it is clear is that fire emissions often have broad-scale impacts on ozone formation[18] and can be decisive factors in triggering air quality exceedances.

Photo oxidation of the NOx and volatile organic compounds ("VOCs" – referred to as "volatile organic material" or "VOMs" by Illinois EPA) emitted by fire plumes shows complex behavior, sometimes leading to production of ozone[19]. Other cases have confirmed that the maximum ozone production is often observed substantially downwind of the fire, after the smoke plumes have aged for several days. Dreessen *et al*[20] noted in their analysis of a June 2015 wildfire that at peak smoke concentrations in Maryland, wildfire-attributable VOCs more than doubled, while non-NOx oxides of nitrogen (NOz) tripled. These findings suggest the long-range transport of NOx within the smoke plume. They also

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[14] Balch, Jennifer K.; Bradley, Bethany A.; D'Antonio, Carla M.; [et al.]. 2013.
Introduced annual grass increases regional fire activity across the arid western
USA (1980–2009). Global Change Biology. 19(1): 173–183

[15] Dick-Peddie, William A. (1999). New Mexico Vegetation: Past, Present, and Future. University of New Mexico Press. p. 280. ISBN 0-8263-2164-X.

[16] Akagi, S. K., et al. (2012), Evolution of trace gases and particles emitted by a chaparral fire in California, Atmos. Chem. Phys., 12(3), 1397-1421, doi:10.5194/acp-12-1397-2012.

[17] Singh, H. B., C. Cai, A. Kaduwela, A. Weinheimer, and A. Wisthaler (2012b), Interactions of fire emissions and urban pollution over California: Ozone formations and air quality simulations, Atmos Environ., 56, 45-51, doi:10/1016/j.atmosenv.2012.03.046.

[18] Pfister, G. G., et al. (2006), Ozone production form the 2004 North American boreal fires, J. Geophys. Res., 111, D24S07, doi:10.1029/2006JD007695.

[19] Jaffe, D.; Wigder, N. Ozone production from wildfires: A critical review. Atmos. Environ. 51, 1−10, 2012.

[20] Dreessen, J. et. Al., Observations and impacts of transported Canadian wildfire smoke on ozone and
aerosol air quality in the Maryland region on June 9–12, 2015. Journal of the Air & Waste Management
Association, 66(9), 842-862, 2016.

noted that ozone peaks a few days after the maximum smoke plume due to ultraviolet light attenuation, lower temperatures, and non-optimal surface layer composition. Putero *et al*[21] observed the largest increases in ozone from fires five days (120 hours) after the initial pollutants were emitted from the fire (Figure 8).

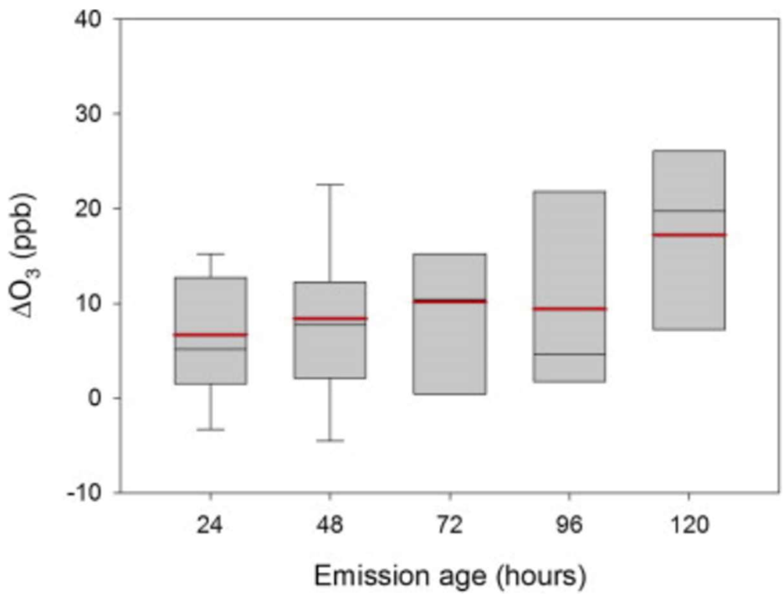

Figure 8. Ozone Enrichment by Age of Plume

[21] Putero, D. et. al., Influence of open vegetation fires on black carbon and ozone variability in the southern Himilayas, Environmental Pollution, vol 184, pp 597-604, 2014.

Meteorological Conditions Driving Smoke and Ozone Transport

Table 3 shows representative meteorological conditions at the Chicago O'Hare International Airport (KORD) from June 16-21, 2020[22]. The high temperatures and low winds shown for June 18 and 19, 2020, are typical ozone formation characteristics in the Lake Michigan region. The average surface winds from the east are representative of the Lake Michigan influence on air quality. The overall collective of the readings indicates a low-level high-pressure system in the region. The increase in wind speed, change in wind direction, and decrease in temperatures in the days following indicate a clearing event at this location associated with the lowering of ozone concentrations.

Upper air 700 millibar (mb) and 850 mb height maps[23], where long range transportation can occur, for June 18-19, 2020, are shown in Figures 9 (700 mb) and 10 (850 mb). Surface pressure maps[24] are provided in Figure 11. Figures 12 and 13 provide surface wind roses[25] and representative 12km resolution North American Mesoscale Forecast System (NAM12)-modeled surface and upper air wind roses of O'Hare International Airport for June 18 and 19, 2020. Soundings from the upper air station at the Davenport, Iowa,[26] and corroborating NAM12-modeled conditions representative of O'Hare airport[27], representing Chicago's upper air conditions on June 18 and 19, 2020, are provided in Figures 14 through 17. Additional figures for June 16-21, 2020, are presented in the Appendices to this document.

Table 3. Meteorological Conditions June 16 to 20, 2020, at Chicago O'Hare International Airport.

Variable	6/16/20	6/17/20	6/18/20	6/19/20	6/20/20	6/21/20
Maximum Temperature (F)	86	87	90	93	91	84
Surface Wind Direction (deg)	ESE	E	E	SE	SSW	SSE
Wind Speed (m/h)	6.0	5.4	5.3	3.8	9.3	6.6

The surface maps (Figure 11) show high-pressure system-dominated meteorological conditions during the event. Figures in Appendix A and B show that upper air and surface winds transported residual wildfire smoke pollutants from the Mississippi Valley as well as freshly- generated wildfire plume pollutants into the upper Midwest between June 16 and June 21, 2020. On June 16 and June 17, a high-pressure region directed the latter wildfire plumes to the north of Chicago while continuing to pull smoke from the south. The movement of the high to the northeast on June 18 allowed these precursors to be transported into Chicago both directly from the fire to the southwest and from the recirculation region to the northeast on June 18 and June 19, 2020.

[22] https://mesonet.agron.iastate.edu/
[23] http://www.spc.noaa.gov/obswx/maps/
[24] Id.
[25] https://mesonet.agron.iastate.edu/
[26] https://rucsoundings.noaa.gov/
[27] https://www.ready.noaa.gov/READYamet.php

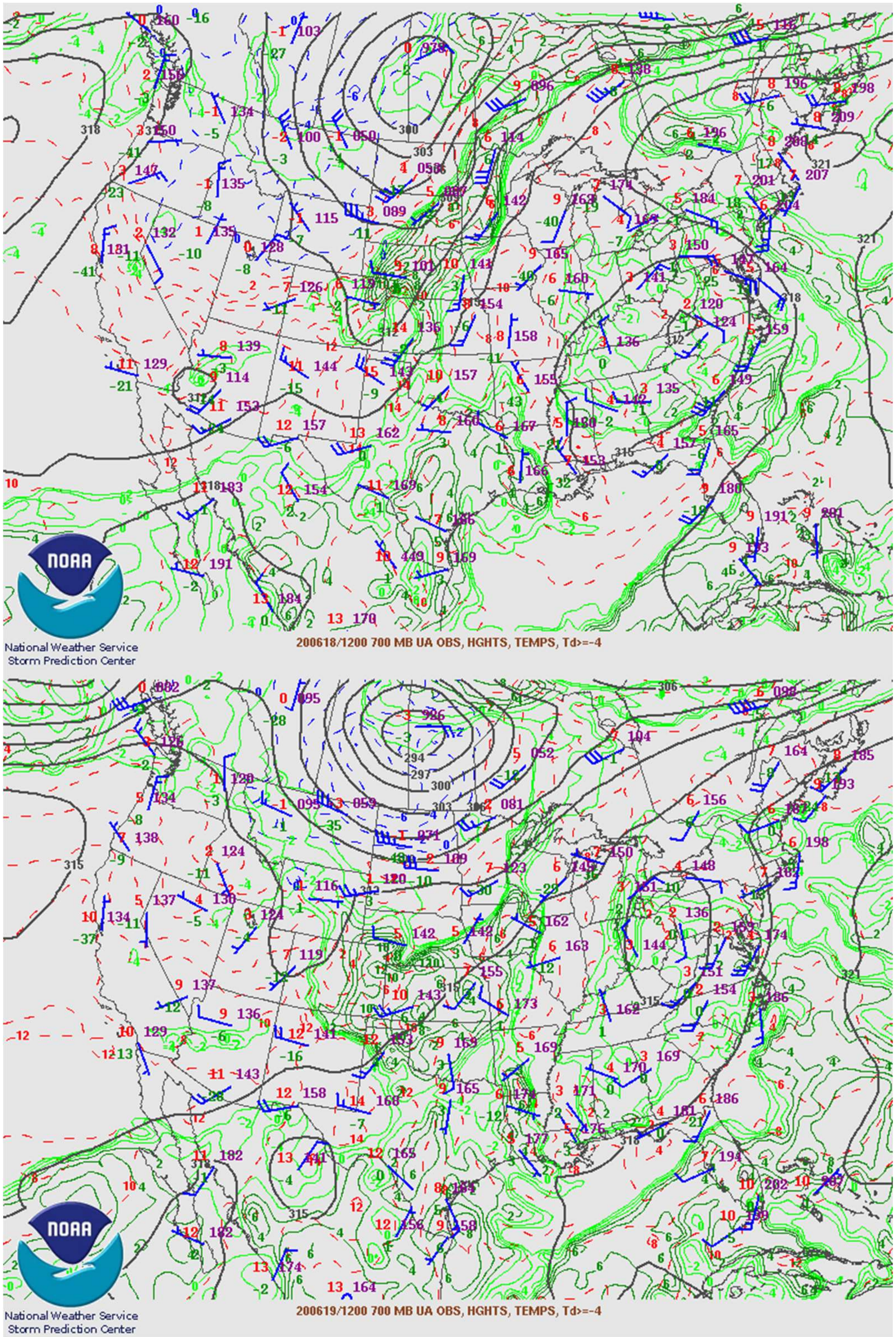

Figure 9. 700 mb Pressure Patterns at 7 am CDT with Winds for June 18, 2020 (top), and June 19, 2020 (bottom)

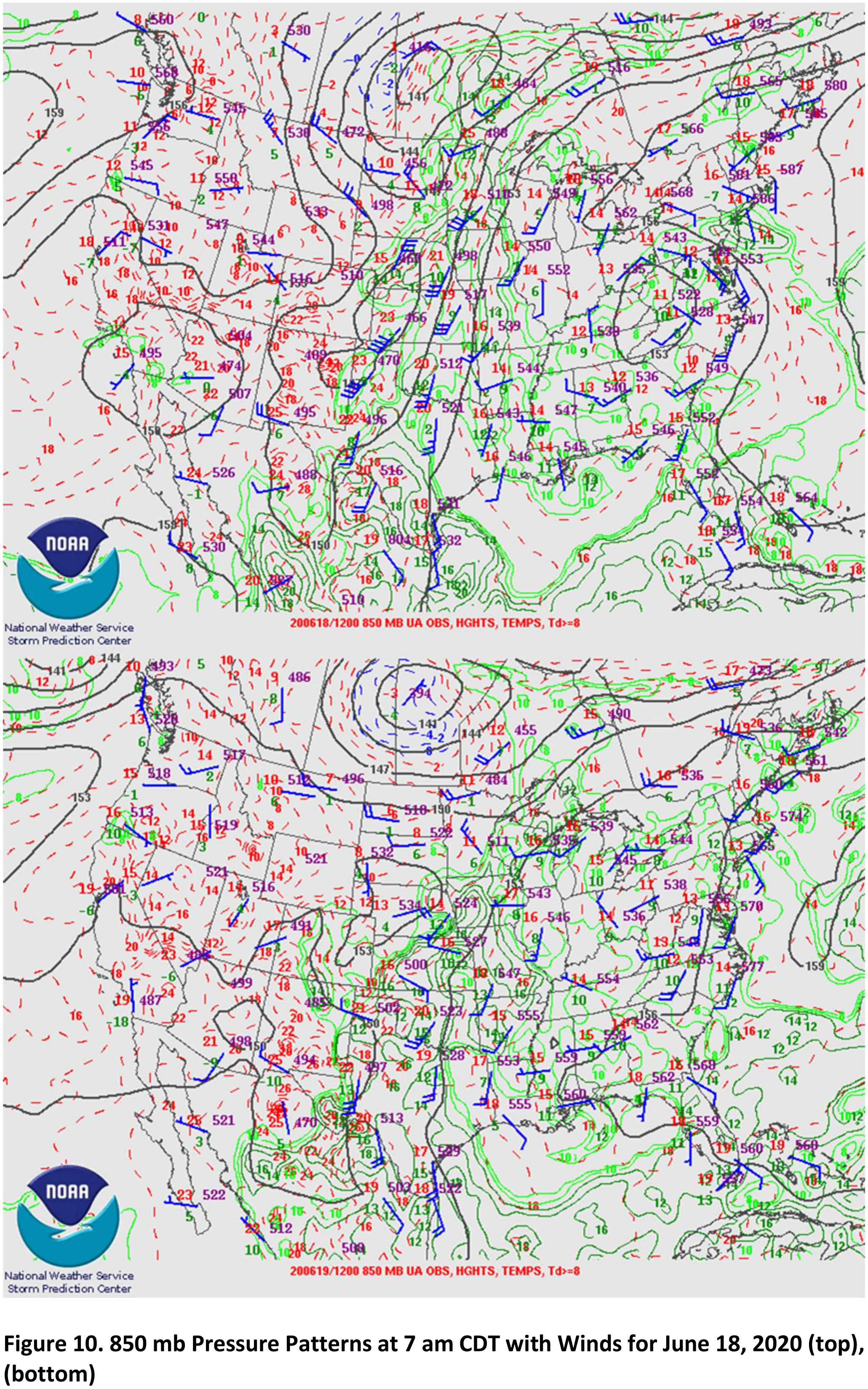

Figure 10. 850 mb Pressure Patterns at 7 am CDT with Winds for June 18, 2020 (top), and June 19, 2020 (bottom)

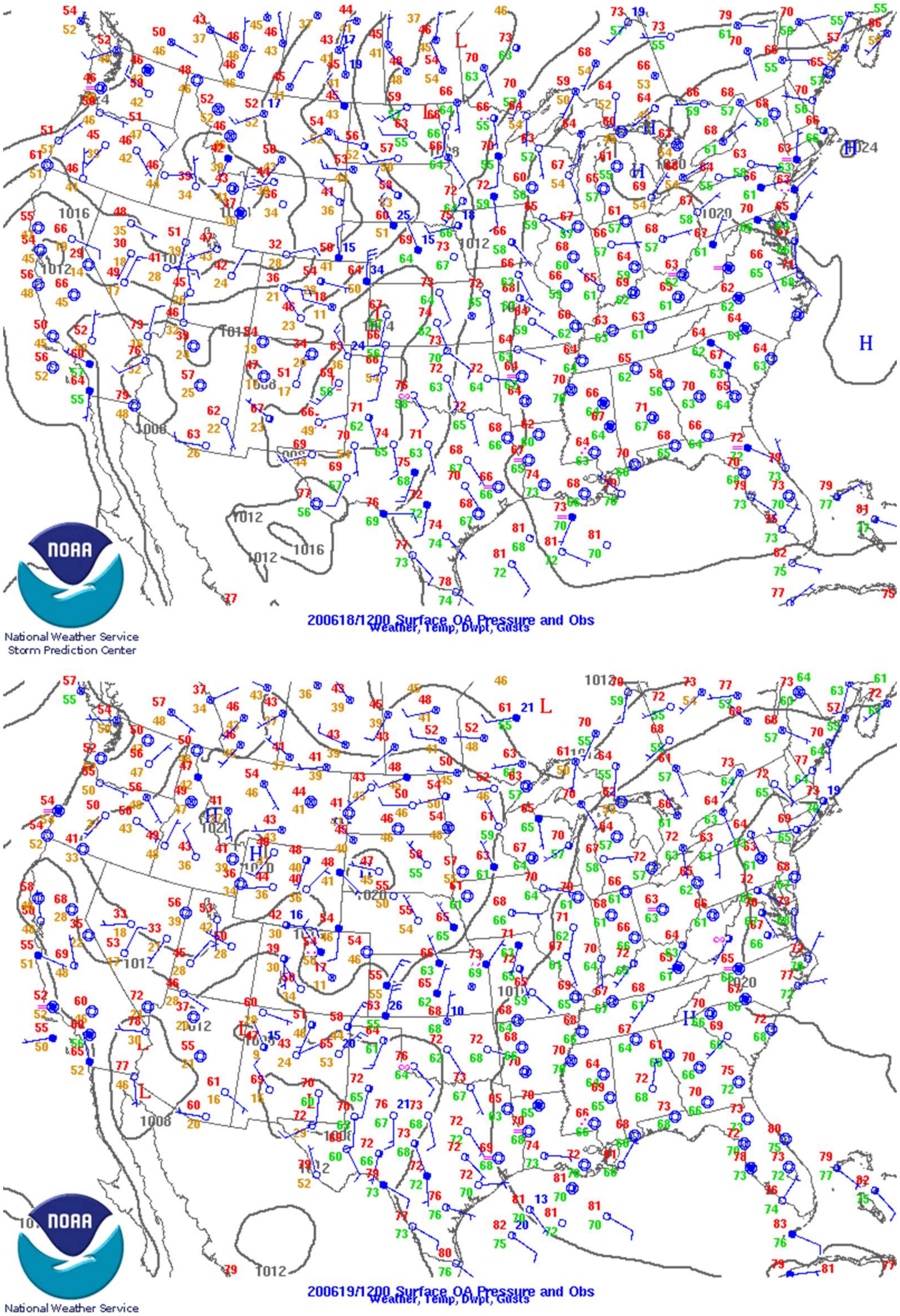

Figure 11. Surface Pressure Patterns at 7 am CDT with Winds for June 18, 2020 (top), and June 19, 2020 (bottom)

The wind roses below (Figures 12 and 13) show the prevailing wind directions divided into sectors around the compass with due north at the top. The longer "petals" of the rose represent sectors where the wind direction is more prominent. Overlaid on these petals are color bars representing specific ranges of wind speed for each wind direction sector. The upper air wind direction and speed were informed using upper air soundings at 700 mb through 850 mb pressures from KORD, representative of Chicago, for 7 am CDT (12Z) on June 18 and 19, 2020. Despite the predominantly eastern flow of surface level winds, the wind roses shown in Figures 12 and 13 indicate the movement of the elevated smoke plume into the area from the south and southwest.

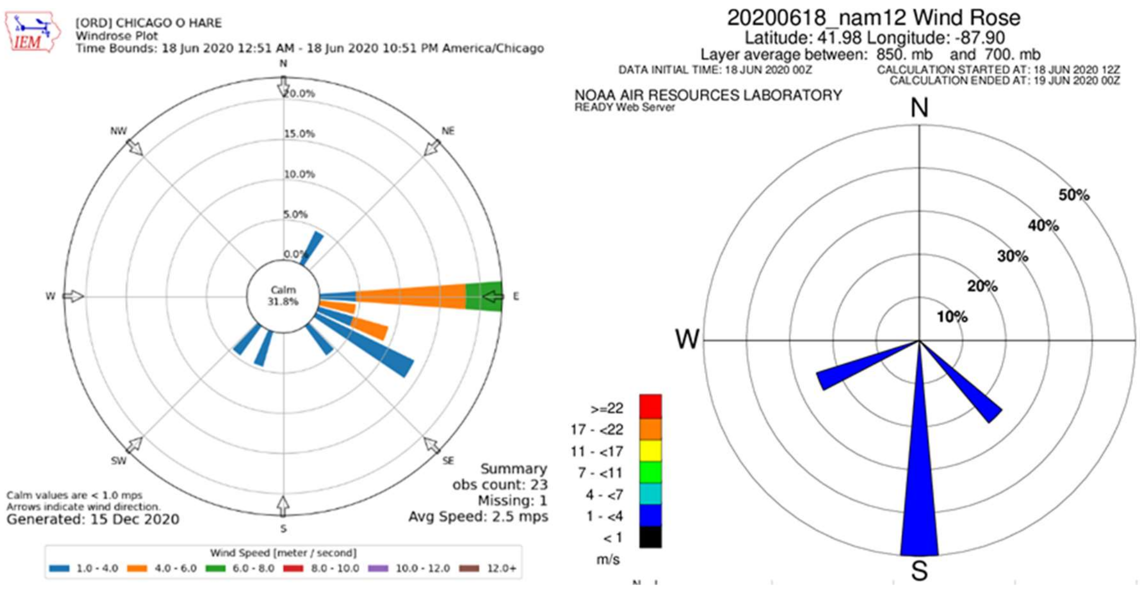

Figure 12. Observed Chicago Surface (left) and Modeled Upper Air (right) Wind Roses for June 18, 2020.

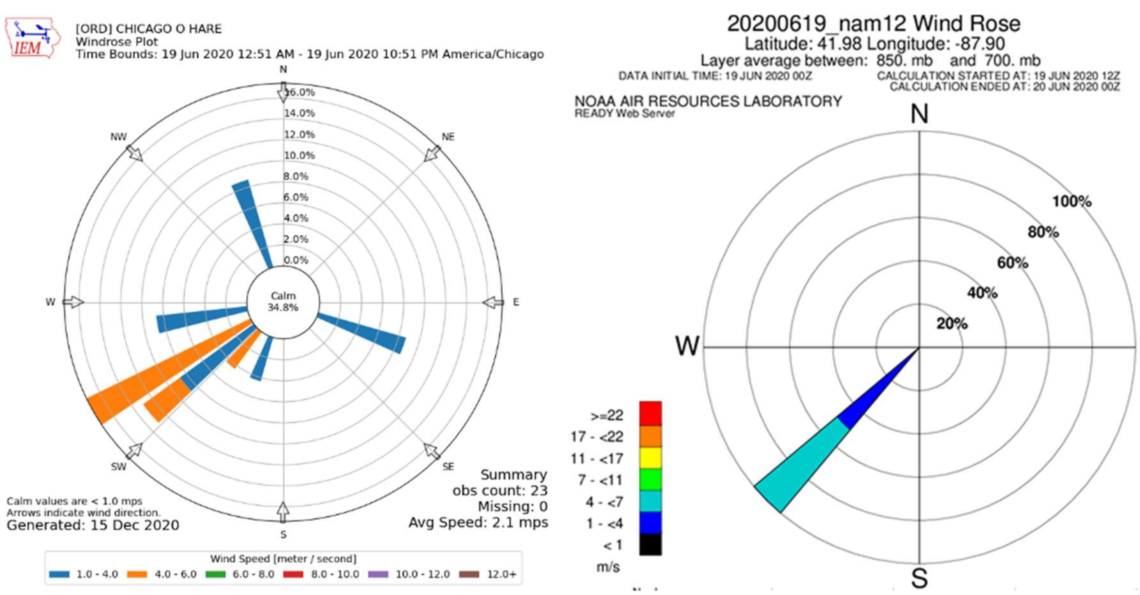

Figure 13. Observed Chicago Surface (left) and Modeled Upper Air (right) Wind Roses for June 19, 2020.

Combining wind rose data with the sounding plots for June 18 and 19, 2020, provided below shows a capping inversion (black circles) for the June 18 (Figure 14) and 19 (Figure 16) morning temperature profiles. The vertical temperature profiles for these mornings showed strong temperature inversions at about 2,000 meters (m) above ground level, the same general altitude as the smoke plume. Evening temperature profiles for June 18 (Figure 15) and 19 (Figure 17) indicate that more vigorous vertical mixing (orange circles) occurred up to the height of the cap. This further supports mixing of the trapped smoke plume to the surface. Smoke that was transported in the upper layer winds and arrived from the south or southwest would have been mixed with surface layer air and would have impacted ozone observations on June 18 and 19, 2020.

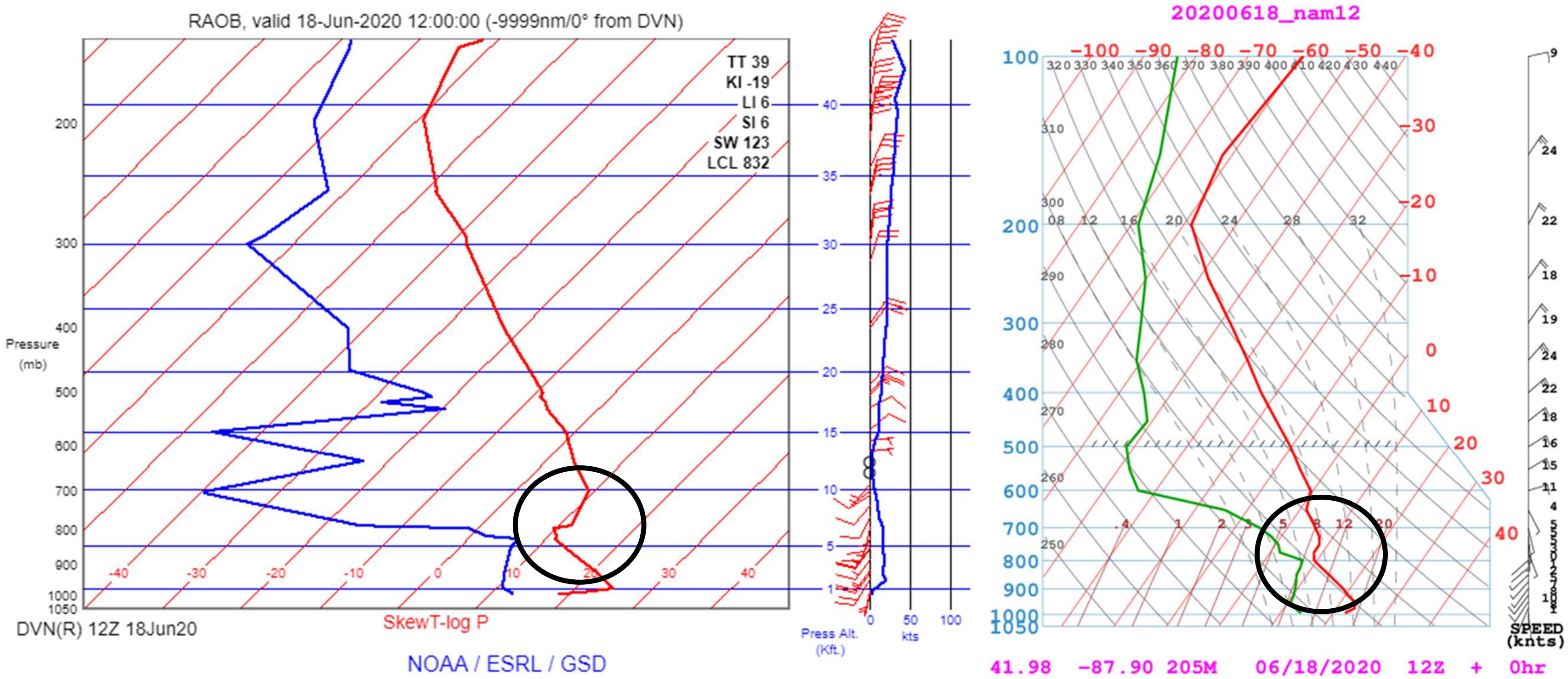

Figure 14. 7 am CDT sounding at Davenport, Iowa (left) and NAM12 modeled sounding for KORD (right) on June 18, 2020, with temperature inversions (circled).

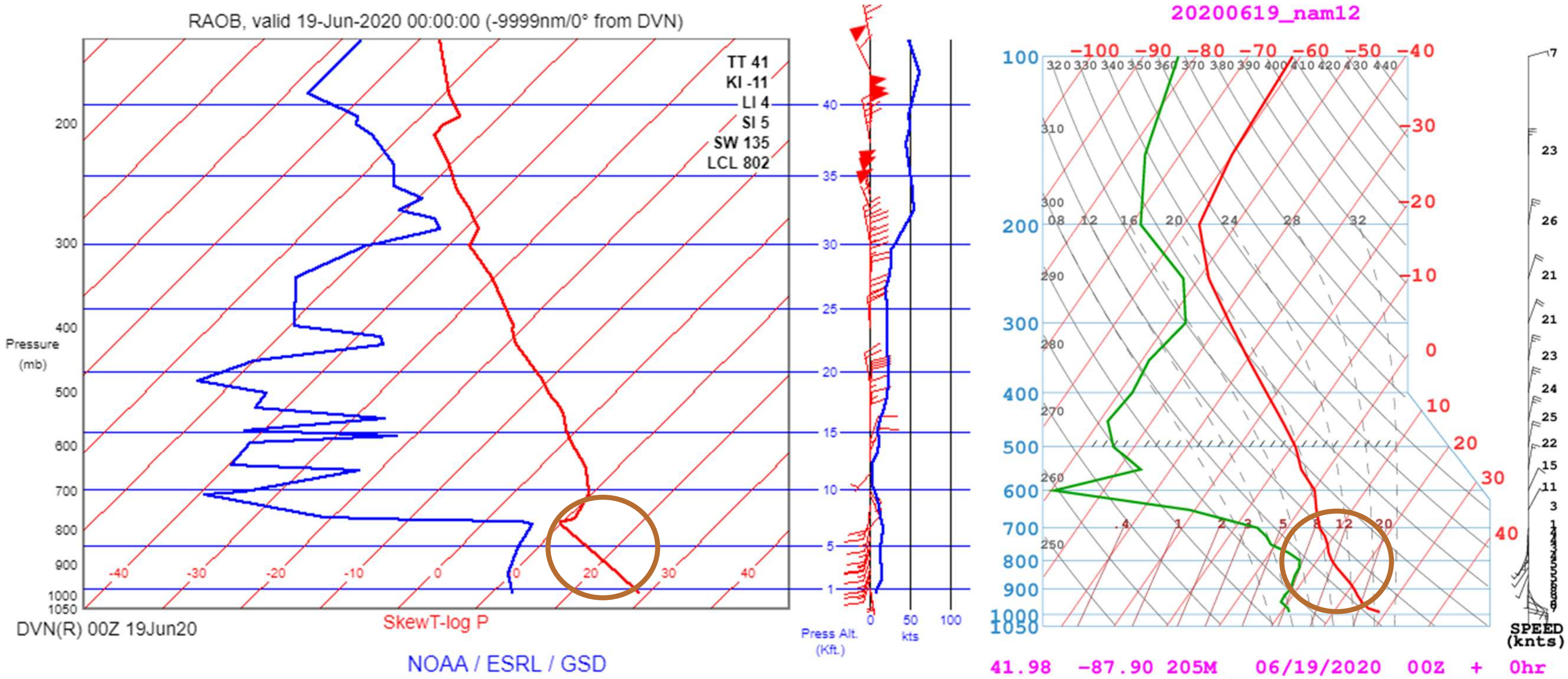

Figure 15. 7 pm CDT sounding at Davenport, Iowa (left) and NAM12 modeled sounding for KORD (right) on June 18, 2020, with more vigorous vertical mixing (circled).

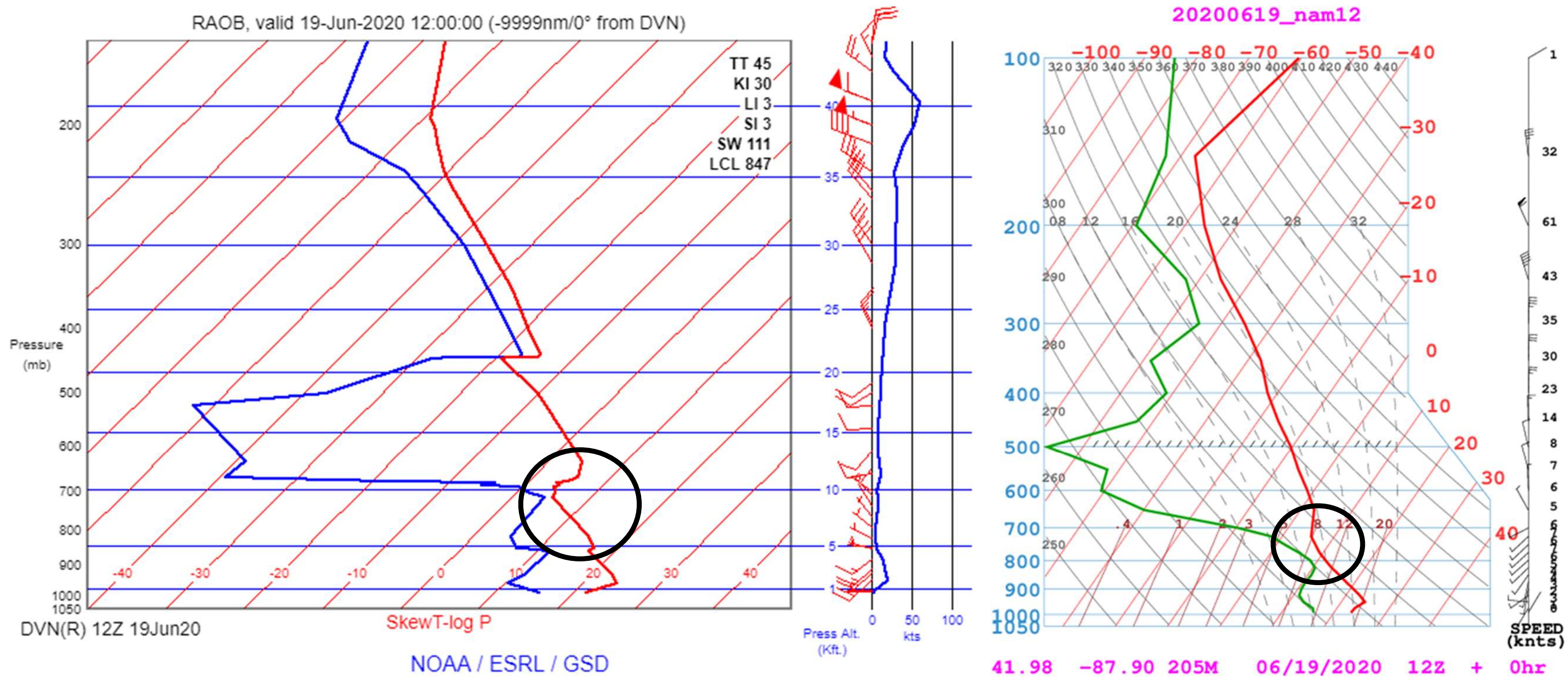

Figure 16. 7 am CDT sounding at Davenport, Iowa (left) and NAM12 modeled sounding for KORD (right) on June 19, 2020, with temperature inversions (circled).

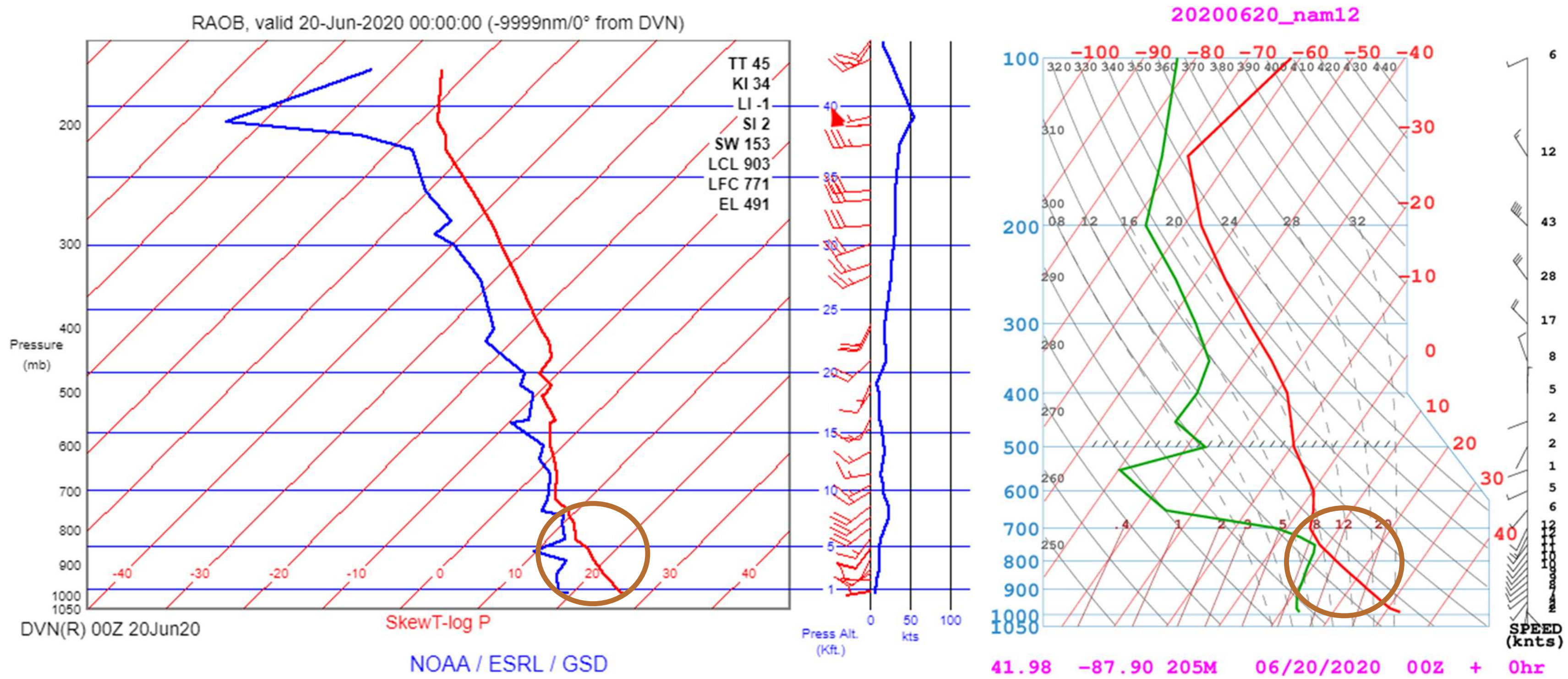

Figure 17. 7 pm CDT sounding at Davenport, Iowa (left) and NAM12 modeled sounding for KORD (right) on June 19, 2020, with more vigorous vertical mixing (circled).

It is important to note that the episode of smoke transport between the Arizona wildfires and the Chicago Northbrook monitor occurred during relatively dry conditions. Figure 18 shows the 24-hour precipitation levels[28] (ending at 7:00 AM EST) for June 17 through 20, 2020. The path from Arizona northeast into the Lake Michigan region during the key dates of June 17 through 19, 2020, has a clear channel of no precipitation. This provides evidence that ozone precursors and particulate matter (PM) species did not precipitate out during the transport from the wildfires to the Northbrook monitor location during this period. On June 20, 2020, precipitation is seen on the western shore of Lake Michigan and in Wisconsin, leaving dry conditions in Michigan and western Ohio.

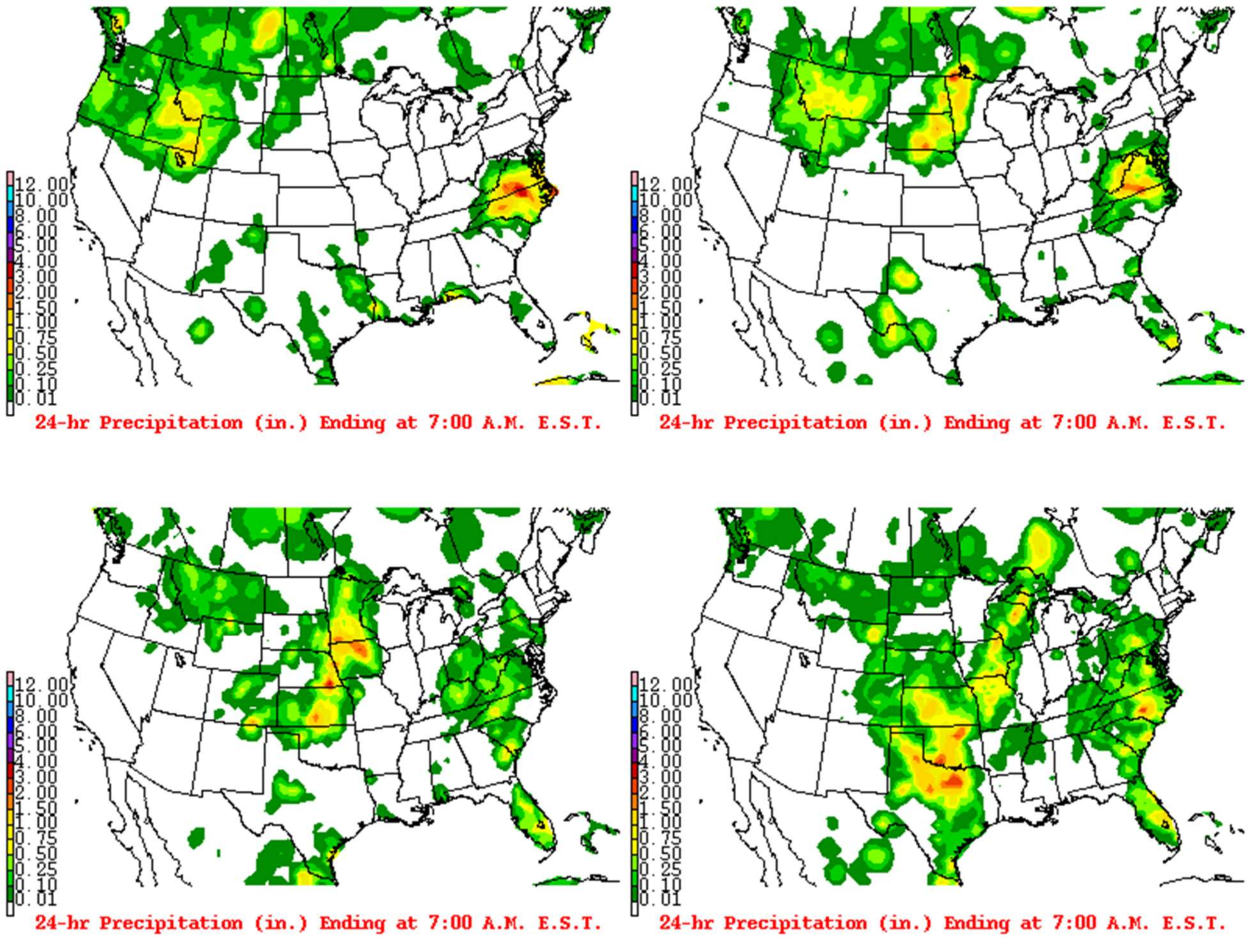

Figure 18. 24-hour Precipitation June 17 (top left), June 18 (top right), June 19 (bottom left), and June 20 (bottom right), 2020

[28] https://www.wpc.ncep.noaa.gov/dailywxmap/

C. Clear Causal Relationship and Supporting Analyses

U.S. EPA's Exceptional Event Guidance outlines a three-tiered approach for the clear causal relationship analysis, along with examples of supporting documentation for each tier.

A Tier 1 demonstration requires the least amount of evidence and is appropriate for wildfires that clearly influenced monitored concentrations, either during a time of year that typically has no exceedances or is clearly distinguishable from non-event concentrations. The June 18-19, 2020, event occurred during the typical ozone season in Illinois and, though concentrations were higher than normal for that time of year, they were not unprecedented. Therefore, a Tier 1 demonstration is not appropriate in this case.

A Tier 2 analysis is necessary when the wildfire impacts are less clear and includes a comparison of the fire emissions to the fire's distance to the monitor (Q/d analysis). Using gridded wildfire emissions data from the Fire INventory of NCAR ("FINN")[29], a Q/d analysis was performed on each of the three individual fires. As the FINN data are represented as molar grid-based estimates and not associated with specific fires, grid cell NOx and reactive VOCs were aggregated from closely related FINN data to estimate the individual fires and converted emissions to tons per day. As each of the fires was located more than 2,000 km away from the Northbrook monitor, daily emissions from any one fire would need to exceed 200,000 tons in order to meet the criteria of a Q/d ≥ 100 tons/km. Illinois' initial Q/d from the Bush Fire Complex (the largest of the three wildfires) was estimated as 0.1 tons/km.

This and the other calculated values for the remaining fires are well below the U.S. EPA recommended level of 100 tpd/km indicating a clear causal relationship. It should be noted that in *none* of the eastern U.S. exceptional events demonstrations approved by U.S. EPA in the past few years and reviewed for comparison to this analysis has the demonstration come close to meeting the Q/d threshold of 100 tons/km. As the Q/d analysis for this area does not satisfy the criteria for clear causality under a Tier 2 demonstration, additional evidence is provided below for a Tier 3 analysis to establish a clear causal relationship.

Comparison of Fire-Influenced Ozone Exceedances with Historical Concentrations

U.S. EPA's Exceptional Events Guidance indicates that a clear-causal demonstration should include a comparison of the event-related exceedance with historical concentrations measured at each monitor requested for data exclusion. Examples of supporting documentation include time-series plots overlaying five years of data and five-year percentiles. The Exceptional Events Guidance indicates that if the flagged data is above the 99^{th} or higher percentile of the five-year distribution of ozone monitoring data or is one of the four highest ozone concentrations within one year, these data can be considered outliers and provide strong evidence for the event.

[29] https://www2.acom.ucar.edu/modeling/finn-fire-inventory-ncar

Figure 19 shows the hourly ozone concentrations from June 13-22, 2020, at the Northbrook monitor in the Chicago area where data exclusion is requested. Increased ozone is evident on June 18 and 19, 2020, as indicated within the grey column. Ozone concentrations were elevated at all sites in Cook County, Illinois, during these dates, demonstrating that Chicago was impacted by an area-wide event. Figure 20 shows an increase in ozone at all monitors in Cook County, Illinois, during the same period with all but one of the monitors with 1-hour observations in the 80-100 ppb levels on at least one of the two episode days. Nine of the ten monitors in Cook County recorded MDA8 ozone concentrations above their 99th percentile values on June 18 and 19, 2020, signifying a rare ozone episode. At all monitors, the observations from these two days were in the top five days of 2020, in many locations they were the top two.

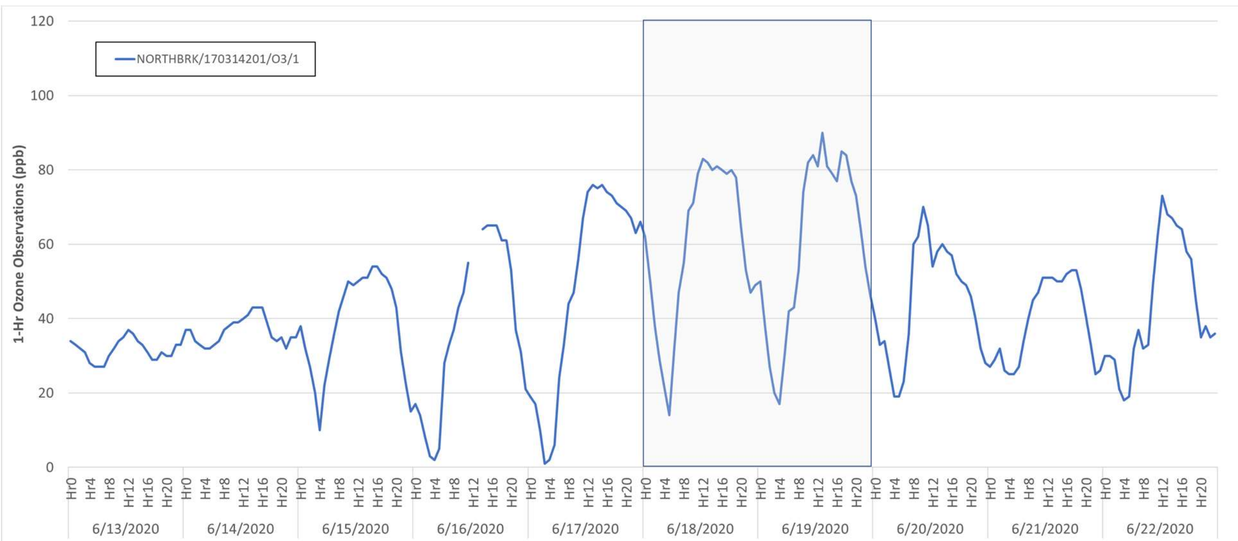

Figure 19. One-hour ozone concentrations from June 13-22, 2020, at the Northbrook monitor.

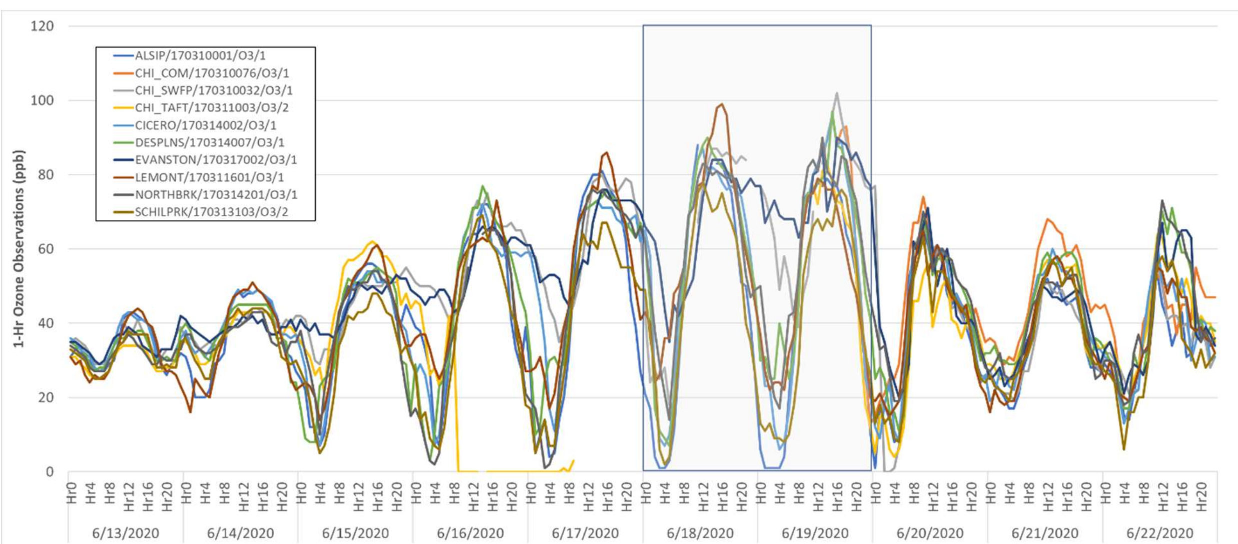

Figure 20. One-hour ozone concentrations from June 13-22, 2020, at all monitors in Cook County, Illinois.

The MDA8 ozone concentrations measured on June 19 (82 ppb) and June 18 (80 ppb) at the Northbrook Water Plant monitor were the second and third highest concentrations in 2020. Figure 21 provides historical context of ozone concentrations at the monitor and presents the MDA8 concentrations across the past five years with the June 18-19, 2020, episode noted on the right-hand side of the graphic. These two dates are among the five observations that exceeded the 75 ppb threshold for the year and are the 11th (June 18, 2020) and 9th (June 19, 2020) highest observations during the past five years. Figure 22 demonstrates that the June 18 and 19, 2020, MDA8 observations were unusually higher, 28.9 ppb and 30.9 ppb higher, respectively, than the five-year June 2016-2020 average MDA8 concentration and more than two times the standard deviation (±13.4 ppb) over this period.

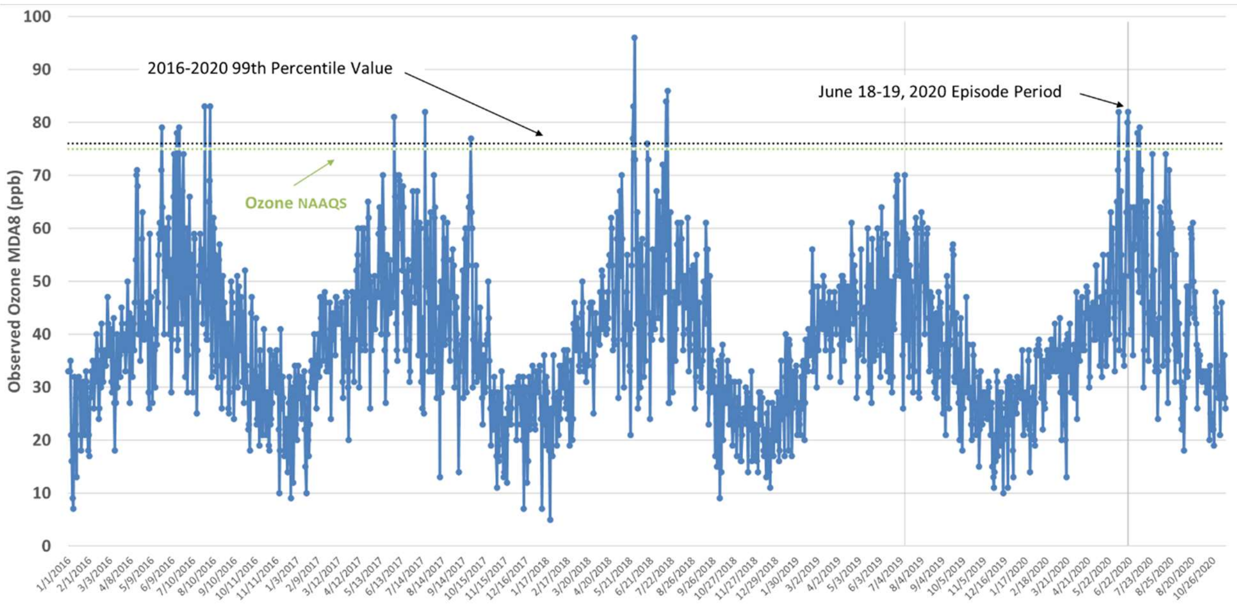

Figure 21. Northbrook (17-031-4201) Daily Maximum 8-hr Ozone 2016-2020

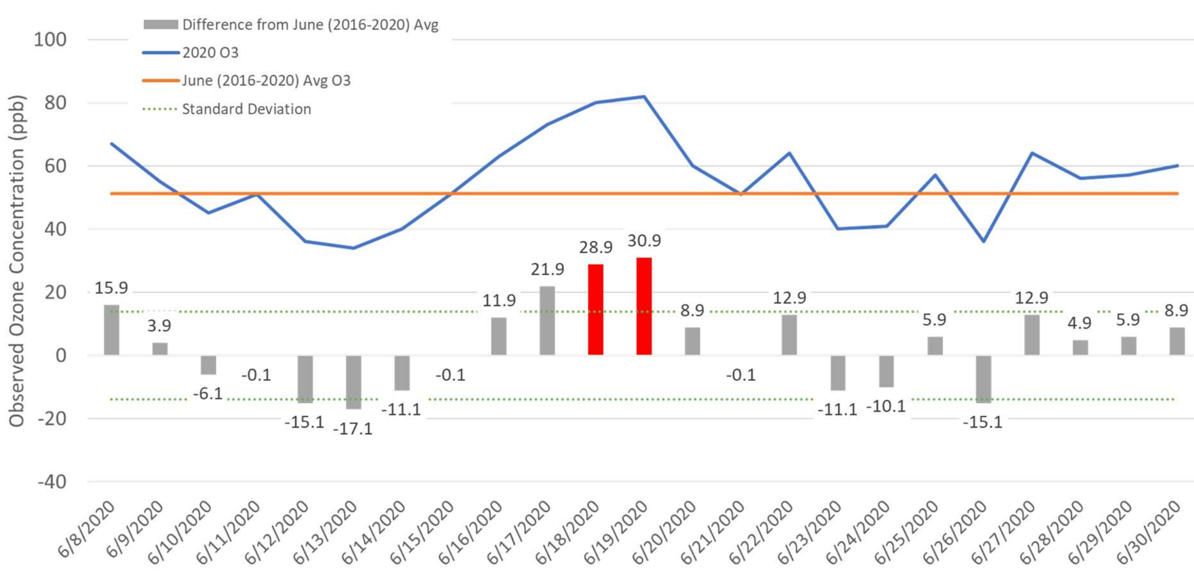

Figure 22. Northbrook June 2020 8-hr Ozone Comparison to June 2016-2020 Average 8-hr.

Table 4 shows the MDA8 ozone levels observed at the Northbrook monitor on June 18 and 19, 2020, compared with the 99th percentile ranked 8-hour ozone levels observed during the last five years.

Table 4. Ozone Five-year (2016-2020) 99th Percentile Comparison for Northbrook Water Plant Monitor.

			Maximum 8-hr Avg Ozone (ppb)		99th Percentile
Monitor ID	**Site Name**	**County**	**6/18/20**	**6/19/20**	
17-031-4201	Northbrook Water Plant	Cook	80	82	77

Figure 23 shows a time-series plot of ozone concentrations at the Northbrook Water Plant monitor for the ozone season overlaying ozone monitoring data from 2016 through November 2020. The black dotted line in this figure represents the five-year 99th percentile value (77 ppb). The green dotted line represents the 2008 8-hour ozone NAAQS of 75 ppb. Each of the five years is represented by colored dots and the two event-related days of June 18 and 19, 2020, are represented as red diamonds.

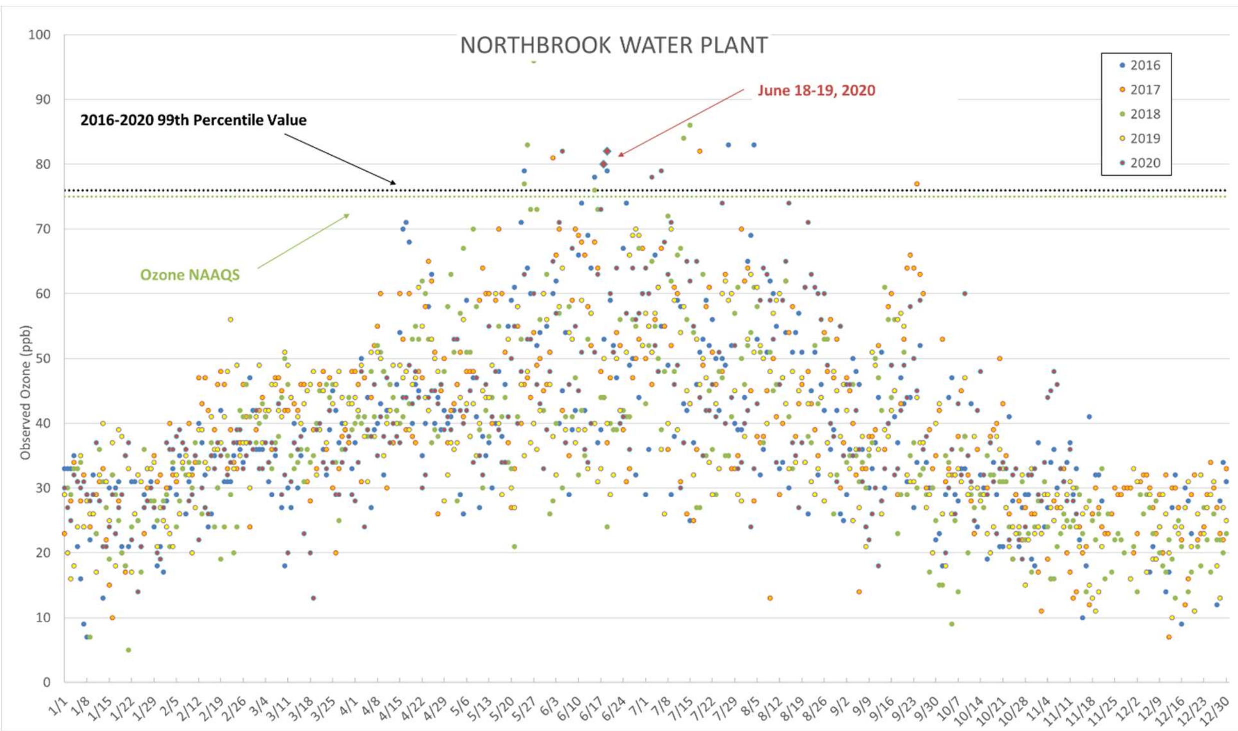

Figure 23. Northbrook Water Plant (17-031-4201) MDA8 values; 2016-2020, color-coded by year

As shown in this figure and table, the June 18 and 19, 2020, ozone data are among the highest concentrations that have occurred over the past five years. While these do not appear to be unprecedented, both dates are above the 99th percentile of such observations. Both were among the four highest ozone concentrations in 2020, thereby meeting the criteria for considering these data outliers. As noted previously, exclusion of data from these two dates may influence demonstrated attainment under the 2008 ozone standard.

Evidence of Transport of Fire Emissions from the Fire to the Monitor

Visible Satellite Imagery

Visible satellite imagery from the Moderate Resolution Imaging Spectroradiometer (MODIS) Aqua and Terra satellites plainly show transport of smoke from fires burning in Arizona to the central and midwestern United States, including Illinois, between June 17 and June 20, 2020, (Figures 24 through 27) when ozone concentrations were at their highest. The movement of a dense smoke plume east and northeast from Arizona between June 11 and June 18, 2020, is particularly noteworthy as this plume eventually makes its way north from the Gulf of Mexico region to join with the northeastern plume over Lake Michigan and surrounding areas, enhancing ozone concentrations along its path.

The associated smoke text product produced by NOAA for June 18, 2020, and represented in Figure 26 notes the following:

> "DESCRIPTIVE TEXT NARRATIVE FOR SMOKE/DUST OBSERVED IN SATELLITE IMAGERY THROUGH 1730Z June 18, 2020
>
> *Large Area from the Southwestern and Central U.S. to the Northeastern U.S. and to the Southeastern U.S./South Central and Southeastern Canada/Northern Gulf of Mexico… Similar to the past couple of days, a very large area of thin density smoke attributed primarily to wildfires burning in the Southwestern U.S. was seen covering the Southwestern, Central, Northeastern, and Southeastern U.S. as well as South Central and Southeastern Canada and the northern Gulf of Mexico. Areas of moderately dense to thick smoke were visible extending from the wildfires in the Southwest to the east and northeast over the Central and Southern Rockies to the Central Plains. The thickest batch of leftover smoke was seen over central New Mexico. New moderately dense to thick smoke was visible emanating from the Mangum, Bush, Bighorn, and Bringham Fires in Arizona."*

The movement of this smoke corresponds to the expansion of elevated ozone values along the pathway of transport to Chicago as demonstrated in following sections using ozone observations, NOAA HMS smoke products, and Ozone AQI maps. In addition, the transport of smoke northeastward from Arizona is consistent with transport patterns seen in the HYSPLIT trajectory analysis and satellite measurements of smoke associated species presented in later sections of this demonstration.

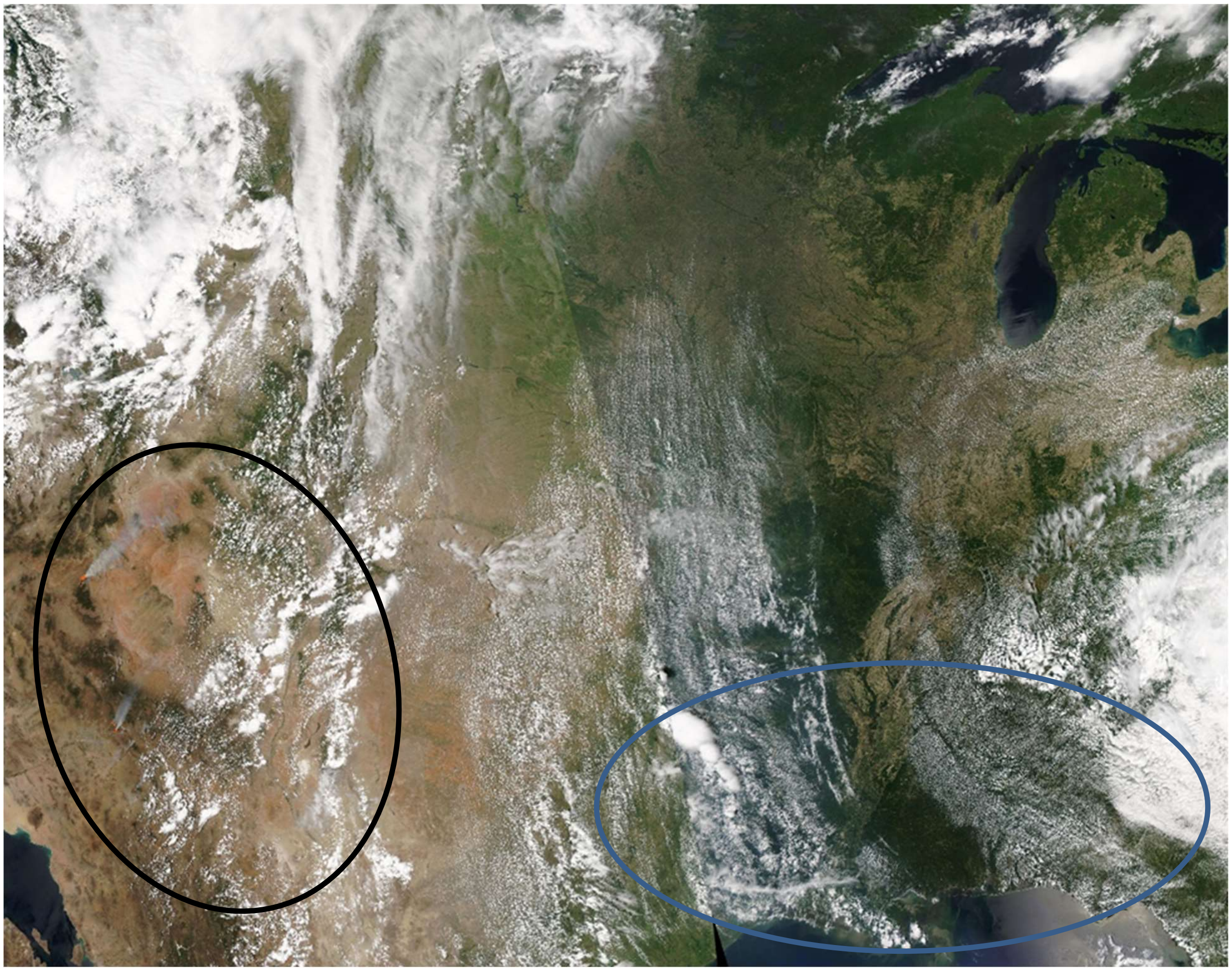

Figure 24. MODIS Aqua true color satellite imagery from June 16, 2020, showing clear evidence of dense smoke plumes associated with the Bighorn, Bush, and Mangum wildfire complexes (black circle) moving in a northeastern direction. Smoke from the wildfires is also seen in the southern states and over much of the northern Gulf of Mexico (blue circle) as it had made its way into the region in the previous days. Image source: NASA Worldview.

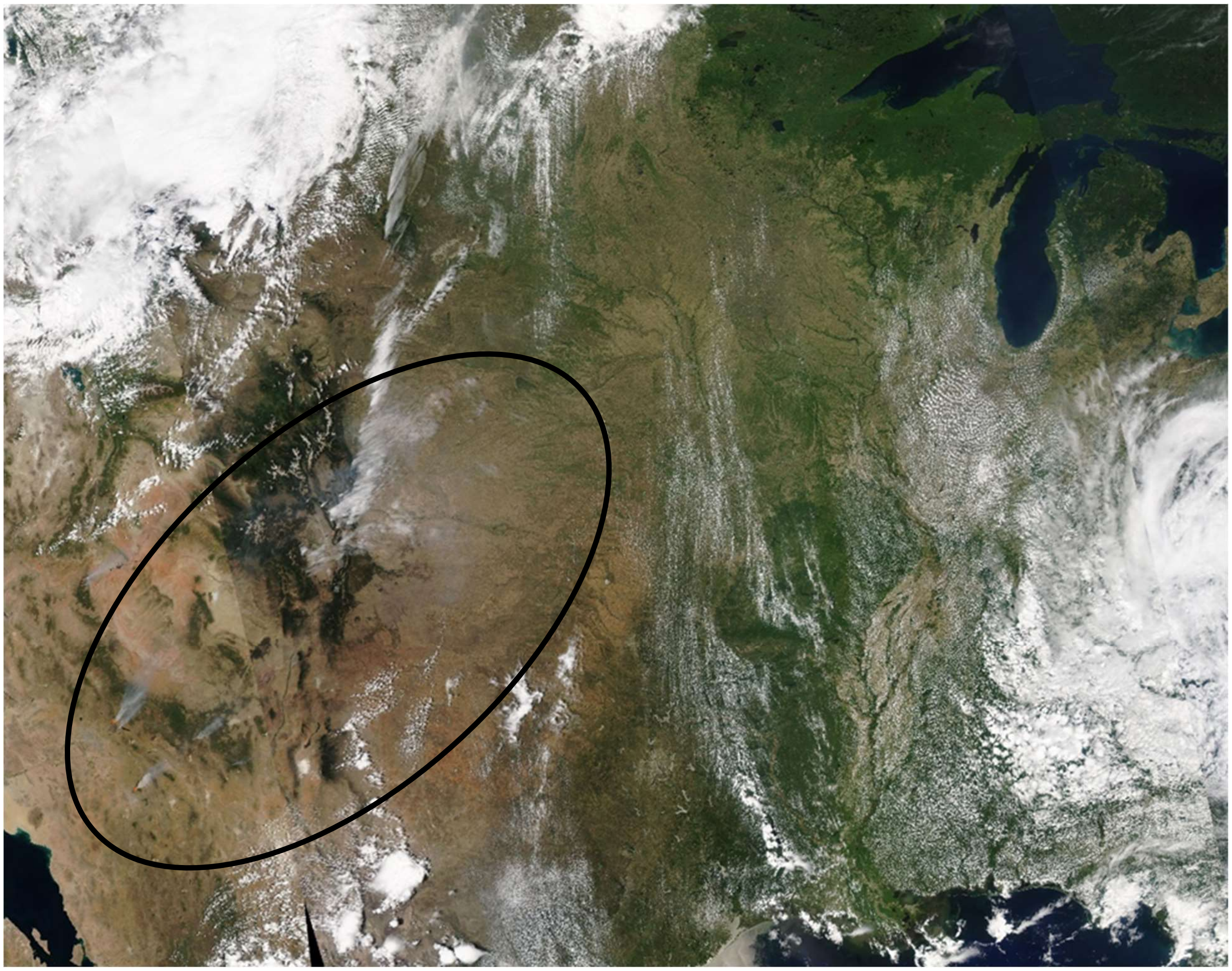

Figure 25. MODIS Aqua true color satellite imagery from June 17, 2020, showing the visible smoke extending eastward with the upper-level jet stream (black circle). Smoke plumes are still seen emanating from the Arizona wildfire complexes. Image source: NASA Worldview.

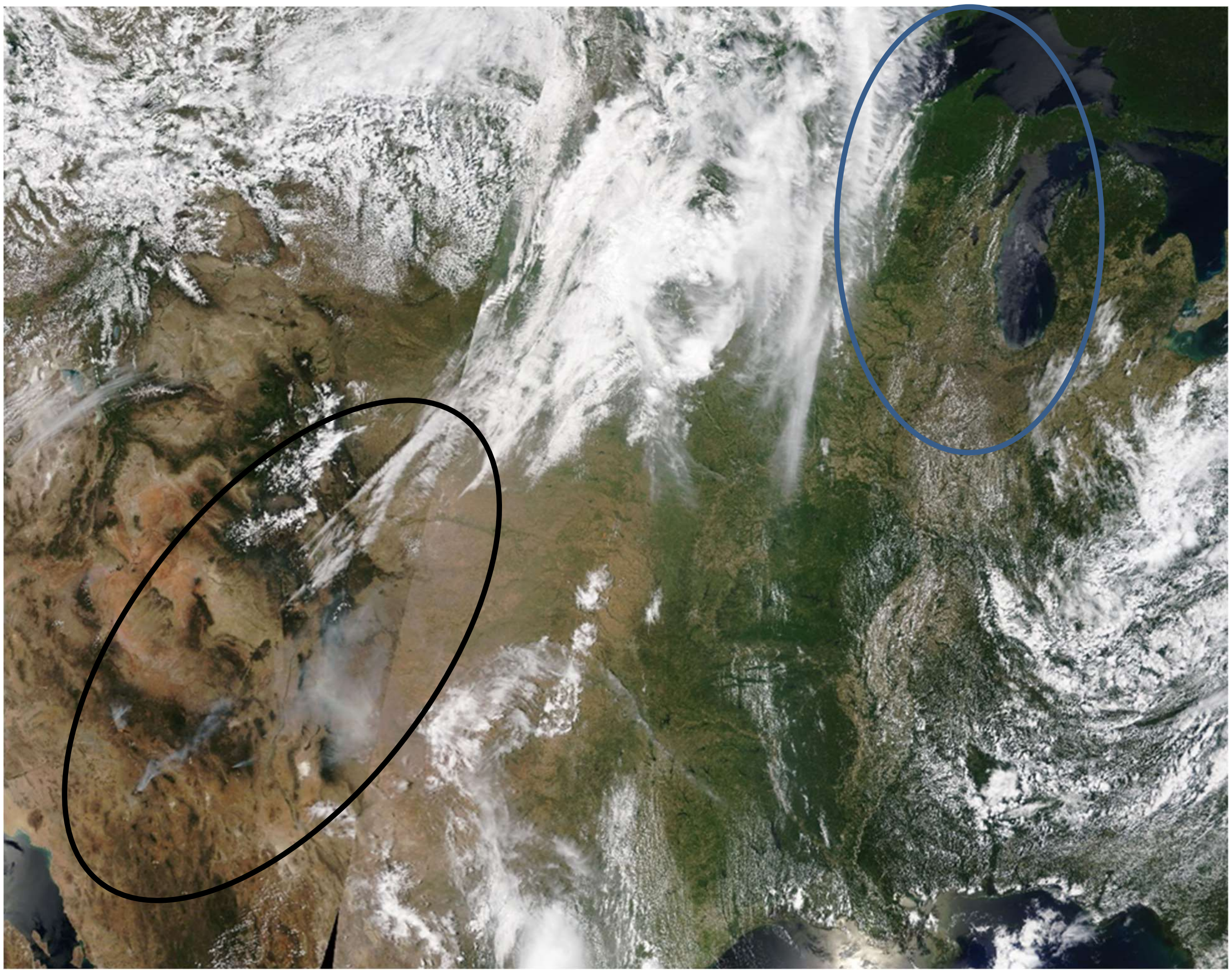

Figure 26. MODIS Terra true color satellite imagery from June 18, 2020, with smoke clearly visibly over the eastern Lake Michigan region after being drawn from the south and pushed in from the west ahead of the weather front (blue circle). Smoke plumes are still seen emanating from the Arizona wildfire complexes (black circle). Image source: NASA Worldview.

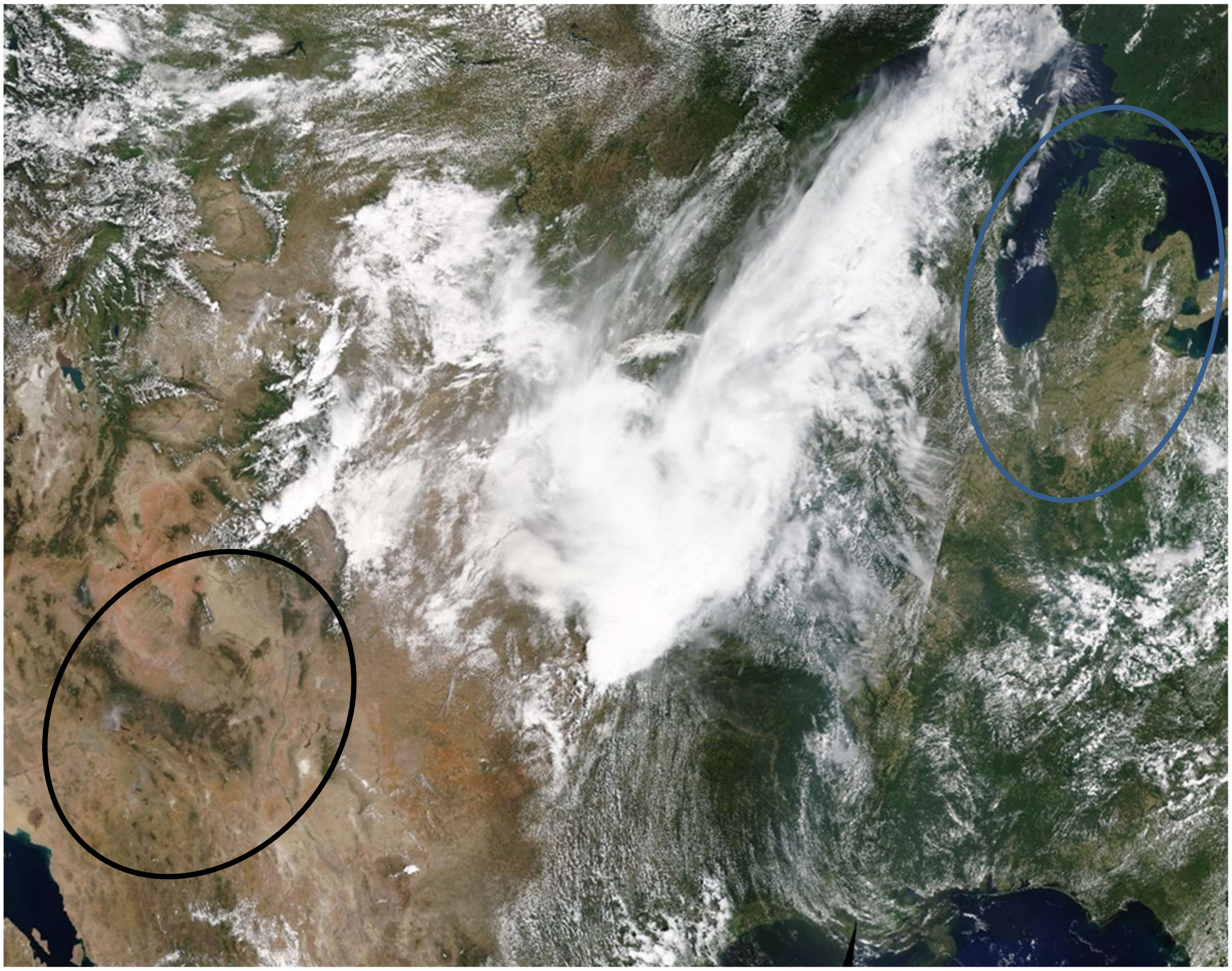

Figure 27. MODIS Terra true color satellite imagery from June 19, 2020, with smoke continuing to be present over the Lake Michigan region as it moves eastward into Michigan and Ohio (blue circle). Smoke plumes are still seen emanating from the Arizona wildfire complexes (black circle). Image source: NASA Worldview.

HMS Fire Detect and Smoke Plume Data and Ozone AQI Maps

Based on the considerable collective size of the Arizona wildfire complexes, significant amounts of ozone and PM2.5 precursors were emitted in addition to other smoke ingredients. As early as June 11, 2020, the plume from the Arizona wildfires began dispersing eastward and north through the Mississippi Valley toward the upper Midwest and Great Lakes region where it would eventually merge with a separate plume from the same fire system and become trapped due to subsidence, atmospheric stability, and light winds associated with a large area of high pressure.

Figures 28, 29, and 30 show the progression of the smoke plumes over North America, as analyzed by the HMS staff at NOAA, using the satellite images and the Ozone AQI. This series of maps shows the movement of the Arizona smoke plumes as a first plume tracks east and then north over the Mississippi Valley while a separate plume on June 16, 2020, moves in a northeastern direction. The plumes meet over the Chicago region during June 18-20, 2020.

As shown in these figures, the Ozone AQI from June 18 and 19, 2020, showed an impact at monitors in Chicago and the surrounding areas. Additionally, the Ozone AQI tracks well with the movement of the densest portion of the smoke plume with highest values coinciding with thickest smoke. Figures 28 through 30 corroborate the evidence of smoke over Chicago demonstrated by the visual satellite images (Figures 24 through 27) that enhanced the ozone concentrations during the June 18 and 19, 2020, episode.

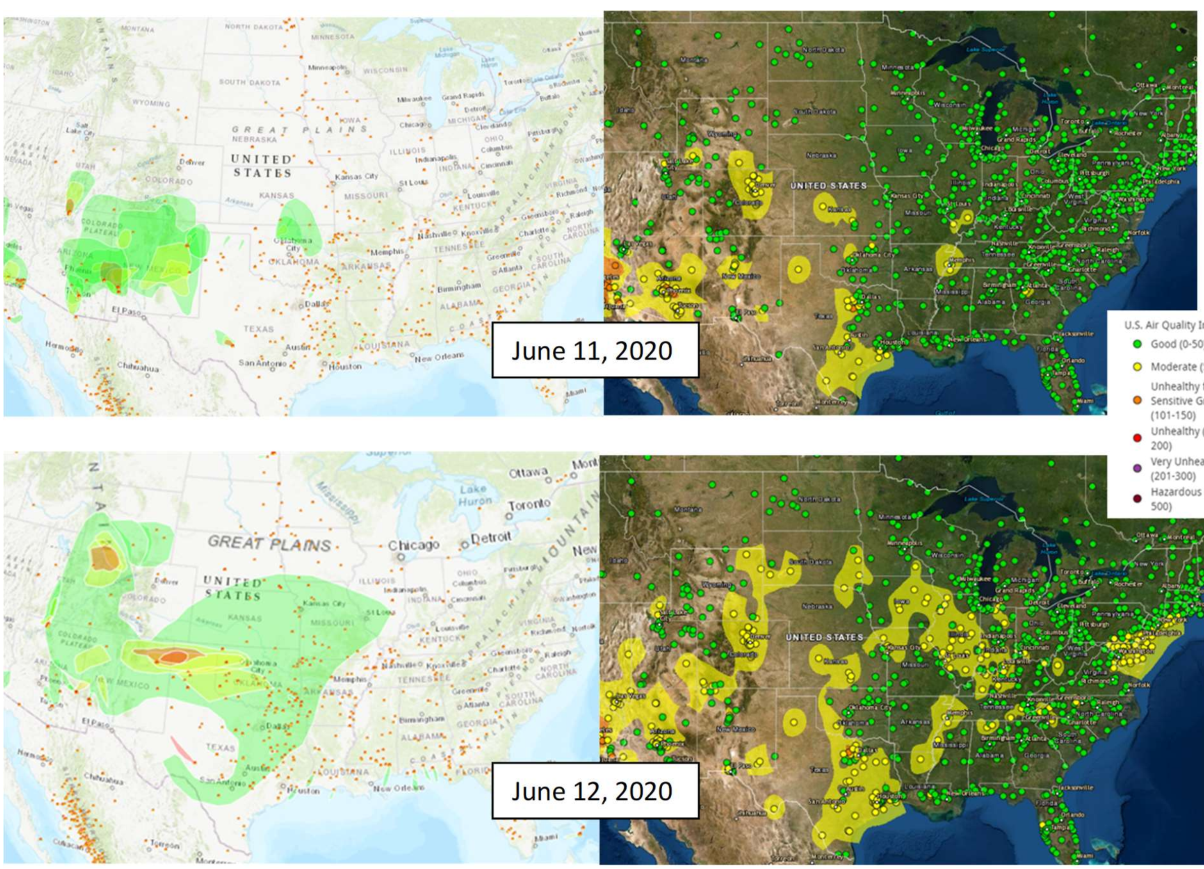

Figure 28. HMS Smoke Analysis (left) and Ozone AQI Maps (right) from June 11-12, 2020.

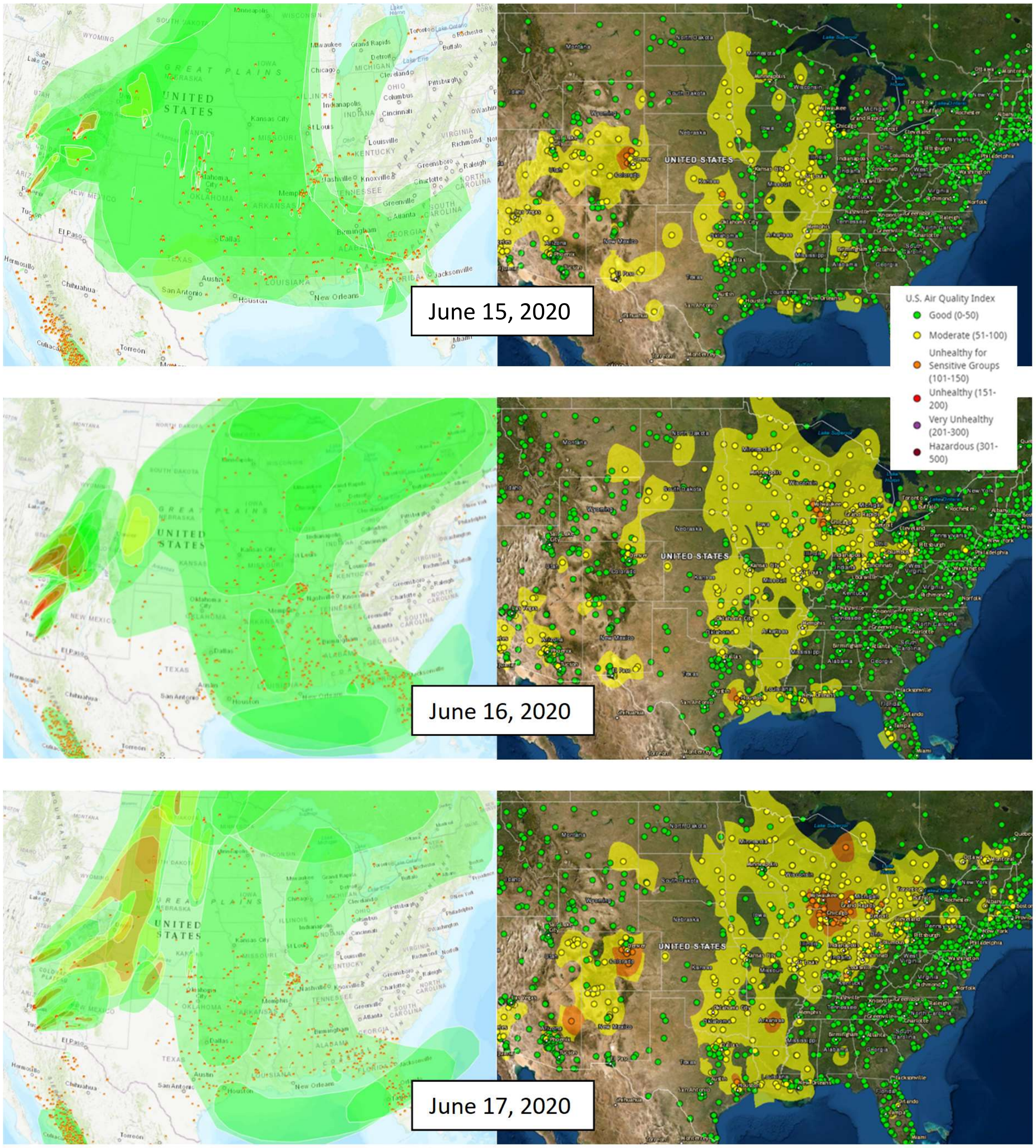

Figure 29. HMS Smoke Analysis (left) and Ozone AQI Maps (right) from June 15-17, 2020.

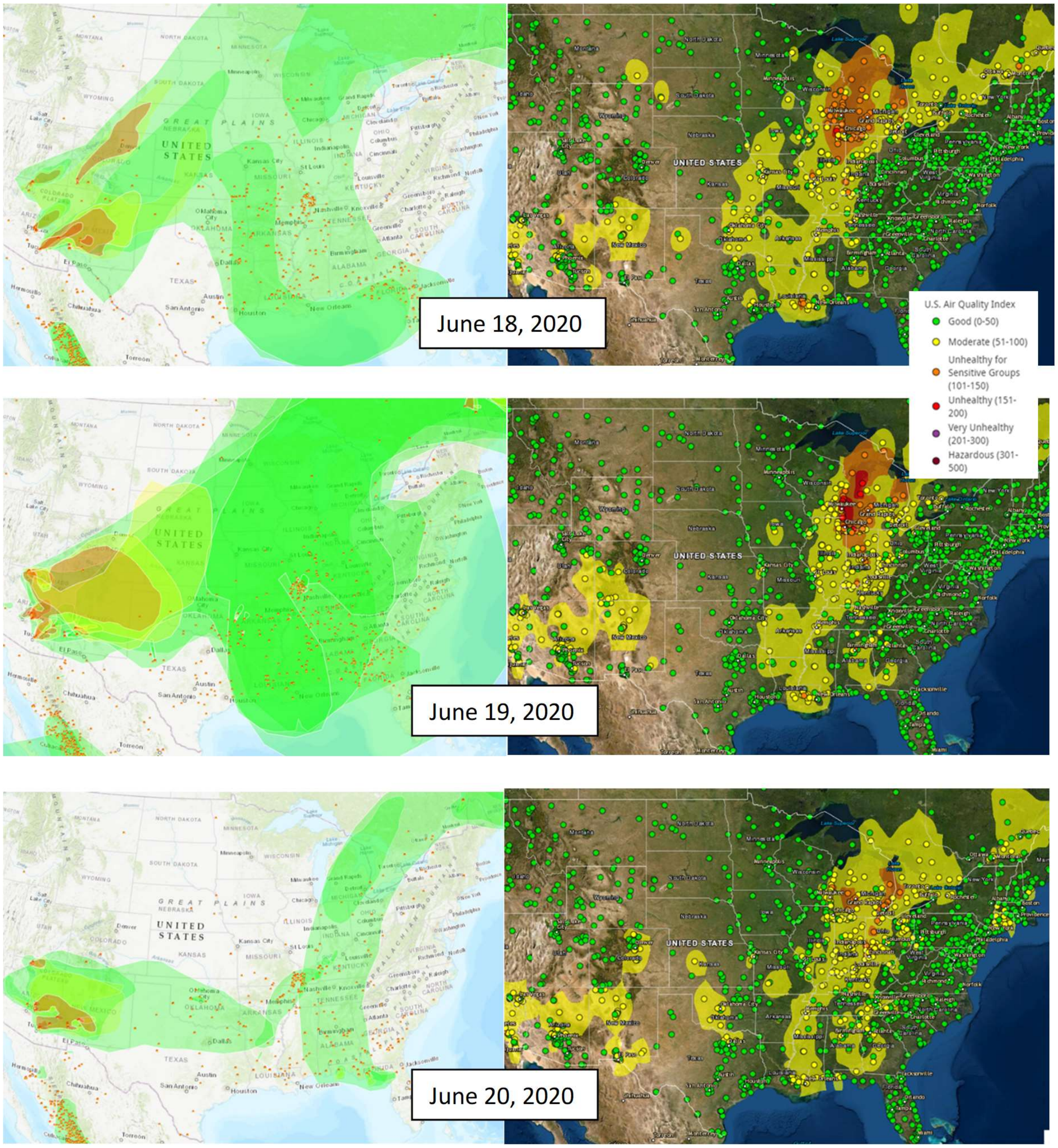

Figure 30. HMS Smoke Analysis (left) and Ozone AQI Maps (right) from June 18-20, 2020.

CALIPSO Analyses

The CALIPSO satellite provides information about the vertical distribution of visible and measured smoke components. CALIPSO combines an active lidar instrument with passive infrared and visible imagers to probe the vertical structure and properties of thin clouds and aerosols over the globe. Detected aerosols are classified into marine, marine mixture, dust, dust mixture, clean/background, polluted continental, smoke, and volcanic aerosol types. Aerosol vertical profiles were retrieved to evaluate the presence of smoke plumes on June 18 and June 19, 2020.

Both CALIPSO retrievals presented below indicate that a mixture of dust, polluted continental, and smoke associated with wildfire plumes were present at the surface layer on both June 18 and 19, 2020. Figures 32 and 34 show profiles that were collected by CALIPSO on episode event days of June 18 and 19, 2020. These profiles, along with HMS smoke products and earlier presented mixing height and vertical temperature profile data, show that the location and altitude of smoke plumes observed over multiple days align with the HYSPLIT trajectories presented below and confirm that smoke in the area reached the surface and enhanced the ozone concentrations in the region. The transport of smoke from Arizona was also confirmed by multiple CALIPSO aerosol profiles collected between June 15 and 20, 2020, and presented in Figure 35.

CALIPSO aerosol retrieval over Chicago for the June 18, 2020, ozone event is available at 2:25 AM local time on June 18. The approximate path of the flyover with the HMS smoke overlay is seen in Figure 31 and travels just west of Chicago and directly over the visible smoke plume. The total attenuated backscatter and vertical profile in Figure 32 shows that a smoke plume (composition polluted dust and polluted continental/smoke) was present on the night of June 18 in a layer between the surface and about 2,000 - 2,500 m above ground level (AGL).

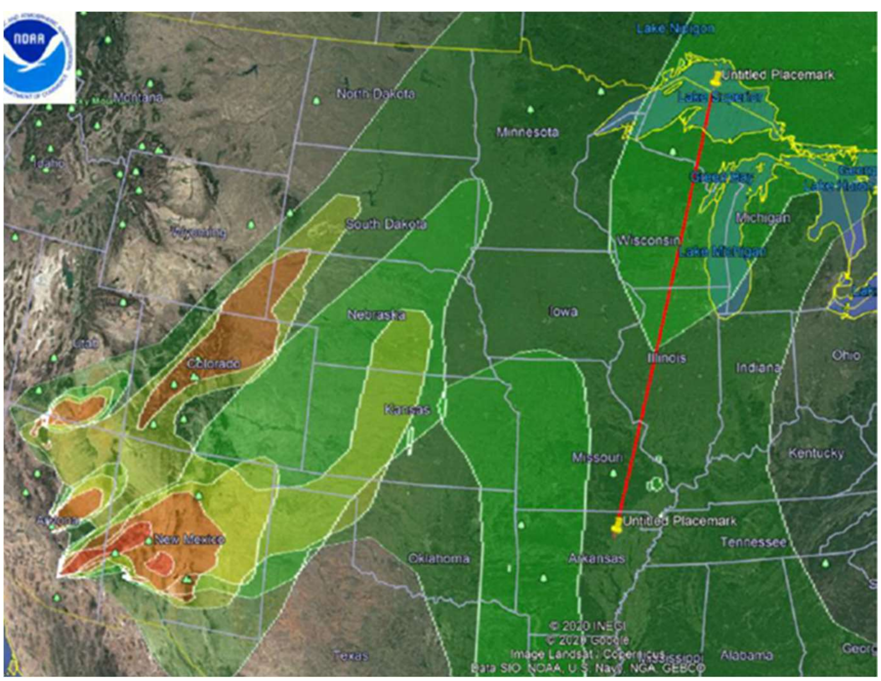

Figure 31. Approximate path of CALIPSO satellite flyover (red line) on June 18, 2020, with HMS smoke overlay. Vertical profiles along the marked path are indicated in Figure 58.

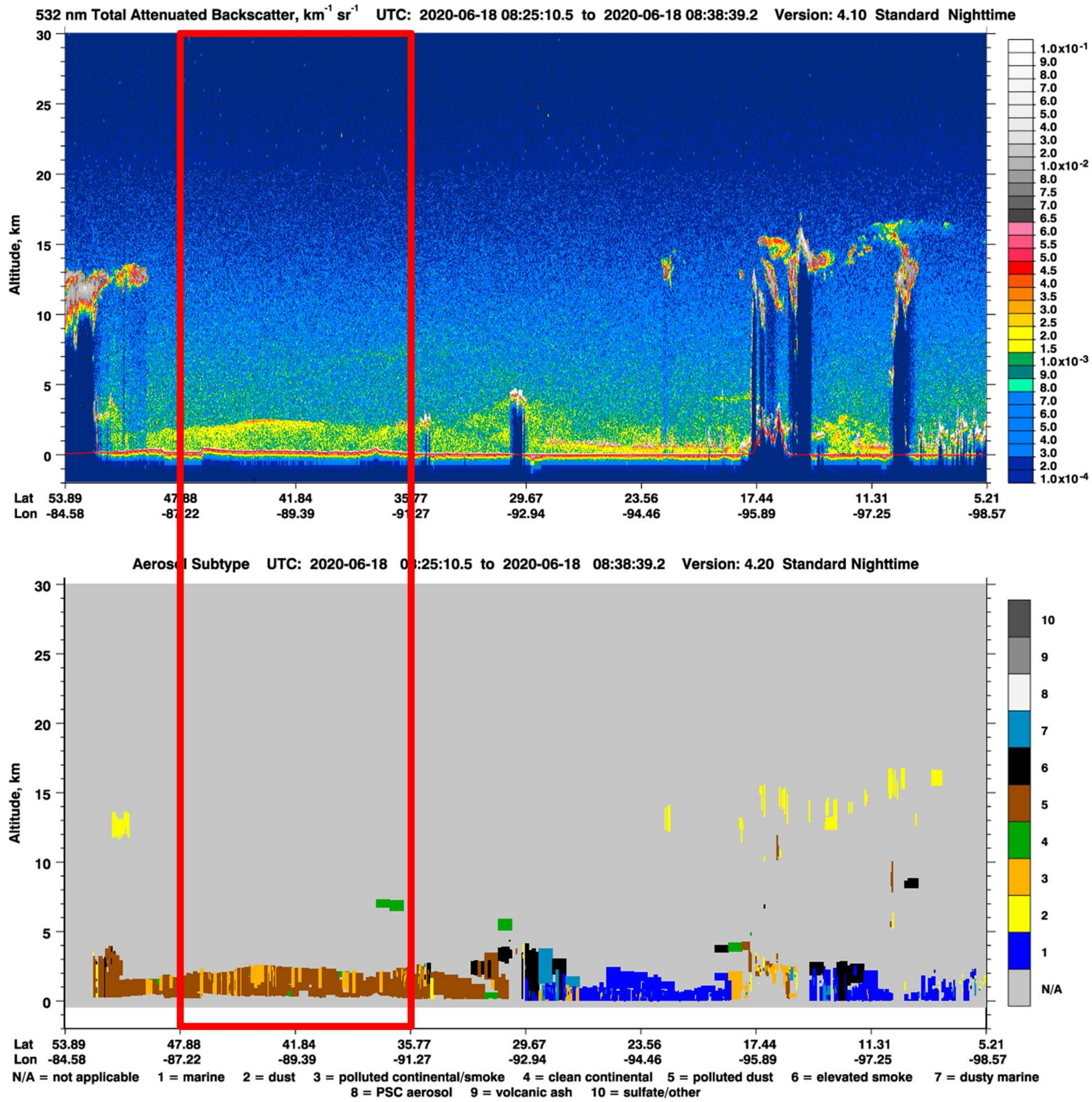

Figure 32. CALIPSO aerosol total attenuated backscatter vertical profile and aerosol subtype at 532 nm, collected on June 18, 2020, between 02:25 and 2:38 a.m. CT over the northern hemisphere. The area enclosed in the red box corresponds to the path marked by the red line in the previous figure. Image source: https://www-calipso.larc.nasa.gov/products/index.php.

CALIPSO aerosol retrieval over the region for the June 19, 2020, ozone event is available at 12:28 PM local time on June 19. The approximate path of the flyover with the HMS smoke overlay is seen in Figure 33. The satellite travels northeast of the region but is still directly over the expansive visible smoke plume. The total attenuated backscatter and vertical profile in Figure 34 shows that a smoke plume (also a composition of polluted dust and polluted continental/smoke) was present during the day of June 19 in a layer between the surface and about 1,500 - 2,000 m AGL.

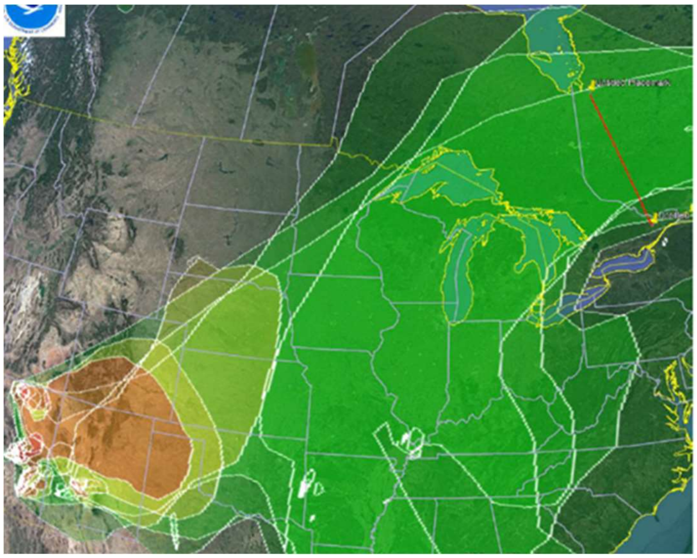

Figure 33. Approximate path of CALIPSO satellite flyover (red line) on June 19, 2020, with HMS smoke overlay. Vertical profiles along the marked path are indicated in Figure 61.

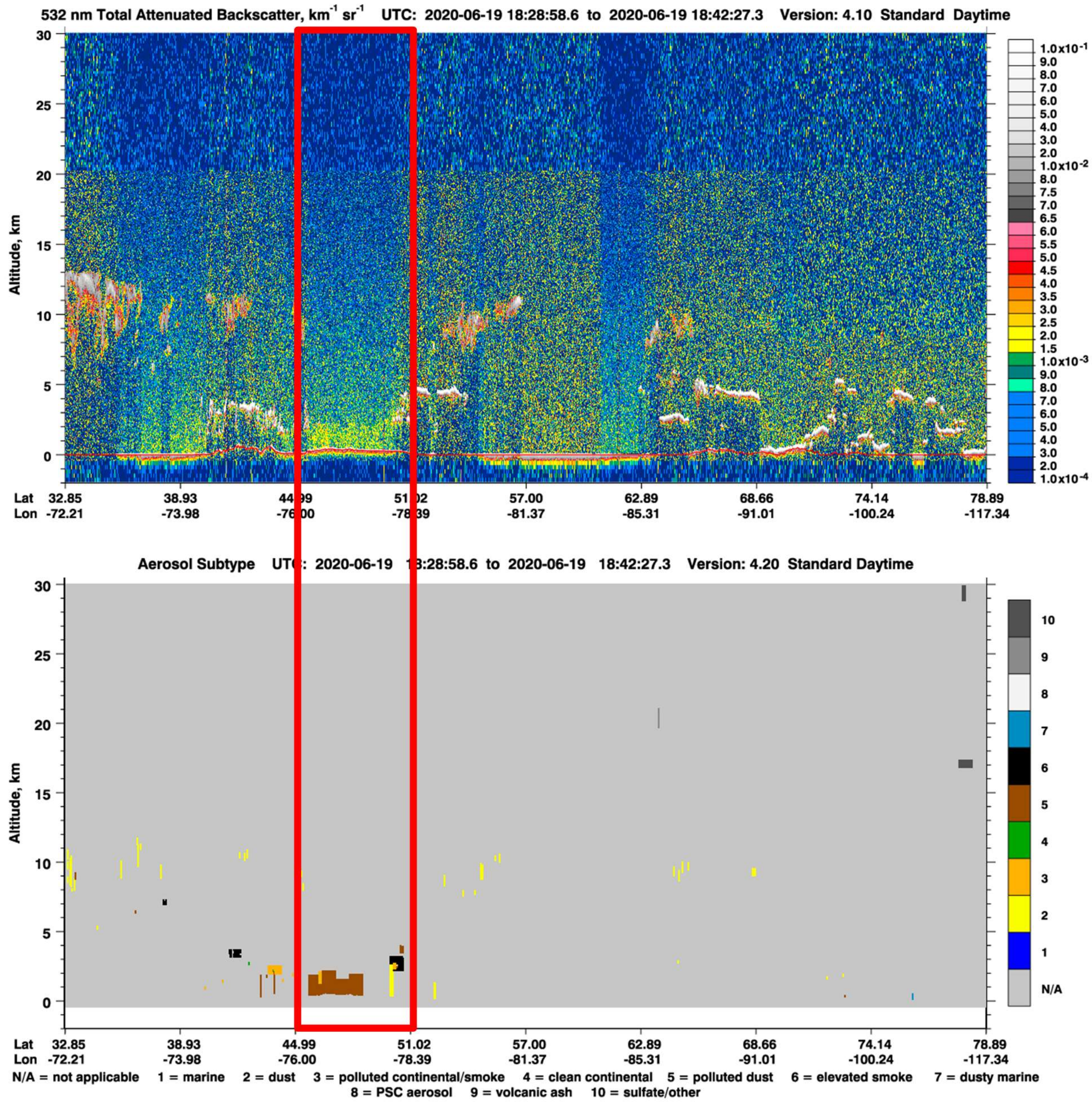

Figure 34. CALIPSO aerosol total attenuated backscatter vertical profile and aerosol subtype at 532 nm, collected on June 19, 2020, between 12:28 and 12:42 p.m. CT over the northern hemisphere. The area enclosed in the red box corresponds to the path marked by the red line in the previous figure. Image source: https://www-calipso.larc.nasa.gov/products/index.php.

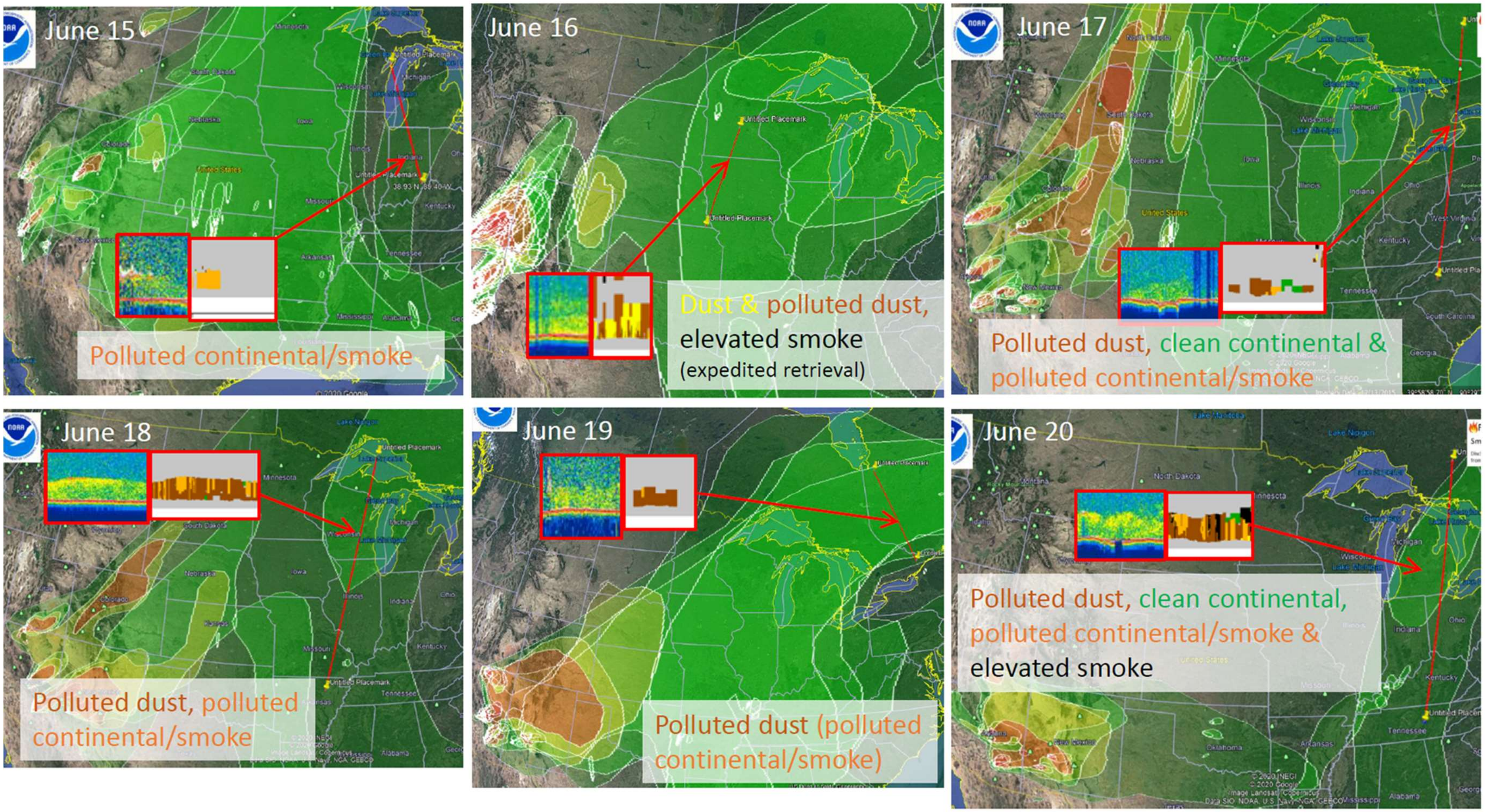

Figure 35. CALIPSO aerosol total attenuated backscatter vertical profile and aerosol subtype summary for June 15-20, 2020. Image source: LADCO presentation.

Regional Upwind Supporting Measurements

Additionally, the comparison of the HMS smoke plumes with MDA8 ozone concentrations shows that ozone concentrations increased at monitors along the paths of the smoke plumes between Arizona, the Mississippi Valley, and the Chicago region. This impact is even clearer based on examination of the four highest ozone concentrations at these sites. Ozone concentrations on many of these dates (Table 5) were within the four highest annual concentrations at many of the monitors along the pathway of the smoke plume. While many of these sites may not have exceeded the level of the ozone NAAQS during this period, it is clearly seen that during the episode of the smoke transport, these sites had unusually high MDA8 ozone concentrations.

Table 5. Observed 1st - 4th High MDA8 Ozone Concentrations (ppb) at Monitors in the Path of the Arizona Wildfire Smoke Plume during the Period June 14–18, 2020 (highlighted).

			MDA8 Ozone Observations (ppb)							
State	County	Monitor ID	1st Max Value	1st Max Date	2nd Max Value	2nd Max Date	3rd Max Value	3rd Max Date	4th Max Value	4th Max Date
Iowa	Linn	19-113-0033	67	06/08/20	64	06/16/20	64	07/03/20	64	08/14/20
Iowa	Scott	19-163-0014	64	06/08/20	63	06/16/20	60	06/17/20	55	06/02/20
Iowa	Van Buren	19-177-0006	66	06/16/20	64	06/08/20	63	06/07/20	59	06/06/20
Kansas	Sedgwick	20-173-0010	72	06/15/20	60	06/13/20	59	06/14/20	57	06/17/20
Kansas	Sedgwick	20-173-0018	62	06/15/20	61	06/05/20	61	06/14/20	60	06/13/20
Kansas	Sumner	20-191-0002	60	06/13/20	60	06/15/20	59	06/14/20	57	04/08/20
Kansas	Trego	20-195-0001	61	06/11/20	61	06/15/20	60	06/26/20	59	06/03/20
Missouri	Andrew	29-003-0001	63	06/03/20	62	06/17/20	60	06/08/20	60	06/18/20
Missouri	Callaway	29-027-0002	66	04/08/20	60	06/16/20	59	06/08/20	59	06/14/20
Missouri	Greene	29-077-0036	61	07/10/20	57	06/15/20	56	06/17/20	55	05/02/20
Missouri	Lincoln	29-113-0004	73	06/07/20	68	06/16/20	65	06/08/20	65	06/17/20
Missouri	Monroe	29-137-0001	65	06/07/20	64	06/16/20	58	04/08/20	56	06/15/20
Missouri	Saint Charles	29-183-1004	70	06/18/20	69	06/07/20	68	06/06/20	65	06/17/20
Oklahoma	Adair	40-001-9009	55	06/17/20	54	06/16/20	53	03/28/20	53	06/22/20
Oklahoma	Canadian	40-017-0101	65	06/17/20	64	08/30/20	62	05/07/20	62	06/13/20
Oklahoma	Carter	40-019-0297	70	06/17/20	69	08/06/20	67	05/01/20	66	05/07/20
Oklahoma	Cleveland	40-027-0049	67	06/17/20	64	05/18/20	64	08/28/20	63	08/30/20
Oklahoma	Oklahoma	40-109-0096	66	06/17/20	65	05/01/20	63	08/30/20	62	08/28/20
Oklahoma	Sequoyah	40-135-9021	58	06/16/20	58	06/17/20	54	06/09/20	53	06/15/20

HYSPLIT Trajectory Analysis

To demonstrate that the Arizona wildfire emissions were transported to the Chicago ozone network, the HYSPLIT model[30] was used to calculate forward trajectories originating from within the smoke plume at the fire sites and backward trajectories from the Northbrook monitor site and Chicago region. All trajectories utilize NAM 12km data for all meteorological input.

Forward trajectories from June 16 through June 21, 2020, are shown in Figures 35, 36, and 37. Trajectories represent the Bighorn, Bush, and Mangum wildfire complexes, respectively. The top left side of each figure shows trajectories at three starting heights: 1000 m AGL (red), 1500 m (blue), and 2000 m (green). The top right side of the figure shows ensemble trajectories using meteorological variations at a starting height of 1000 m. The bottom image represents the forward trajectory with the HMS smoke overlay from June 19, 2020, to demonstrate the transport plume associated with the fire. These forward trajectories clearly show transport from the fire and smoke locations towards Lake Michigan, which is consistent with the path of the HMS analysis presented in Figures 29 and 30. The vertical distribution in trajectories for the Bush and Mangum wildfires also demonstrate transported emissions from the smoke subsiding downwards, reaching near surface on June 18 and 19, 2020 (Figures 36 and 37).

Figures 38 to 40 show backward trajectories from the Chicago Northbrook monitor from June 18 to June 20, 2020. The top left side of each figure shows back-trajectories at three starting heights: 10 m AGL (red), 100 m (blue), and 500 m (green). These trajectories were initiated at different starting heights to capture transport throughout the mixed boundary layer, as ozone precursors were transported aloft and influenced concentrations at the surface through vertical mixing. On the days of the events, as shown in the earlier CALIPSO analysis, smoke was present over the region at altitudes from ground level up to about 2,000 m. Regional observations of mixing heights at Davenport, Iowa and modeled soundings at O'Hare International Airport on June 18 and 19, 2020, provide evidence that smoke mixed into the lower levels of the atmosphere during this episode.

The top right side of each figure shows ensemble trajectories using meteorological variations at a starting height of 10 m. The bottom image represents the backward trajectory with the HMS smoke overlay from 48 hours prior to demonstrate how the transport plume associated with the fire made its way into the Chicago area. These figures demonstrate that wildfire smoke which had moved in from the Mississippi Valley and upper Midwest just before the June 18, 2020, episode day was resident over the region and enhanced ozone concentrations on the days of the ozone events on June 18 and 19, 2020, as it continued to be drawn into the region through June 20, 2020.

From these figures, it is easy to see that wildfire smoke had been transported into the region during the June 17 through 20, 2020, timeframes and then was present within the Lake Michigan area as meteorological conditions allowed for the transport of the plume to the Northbrook monitor location. Varying back trajectory starting heights were used to demonstrate the transport of ozone precursor emissions throughout the mixed boundary layer, where vertical mixing of the plume to surface levels enhanced ozone concentrations at the monitor.

[30] https://www.ready.noaa.gov/HYSPLIT.php

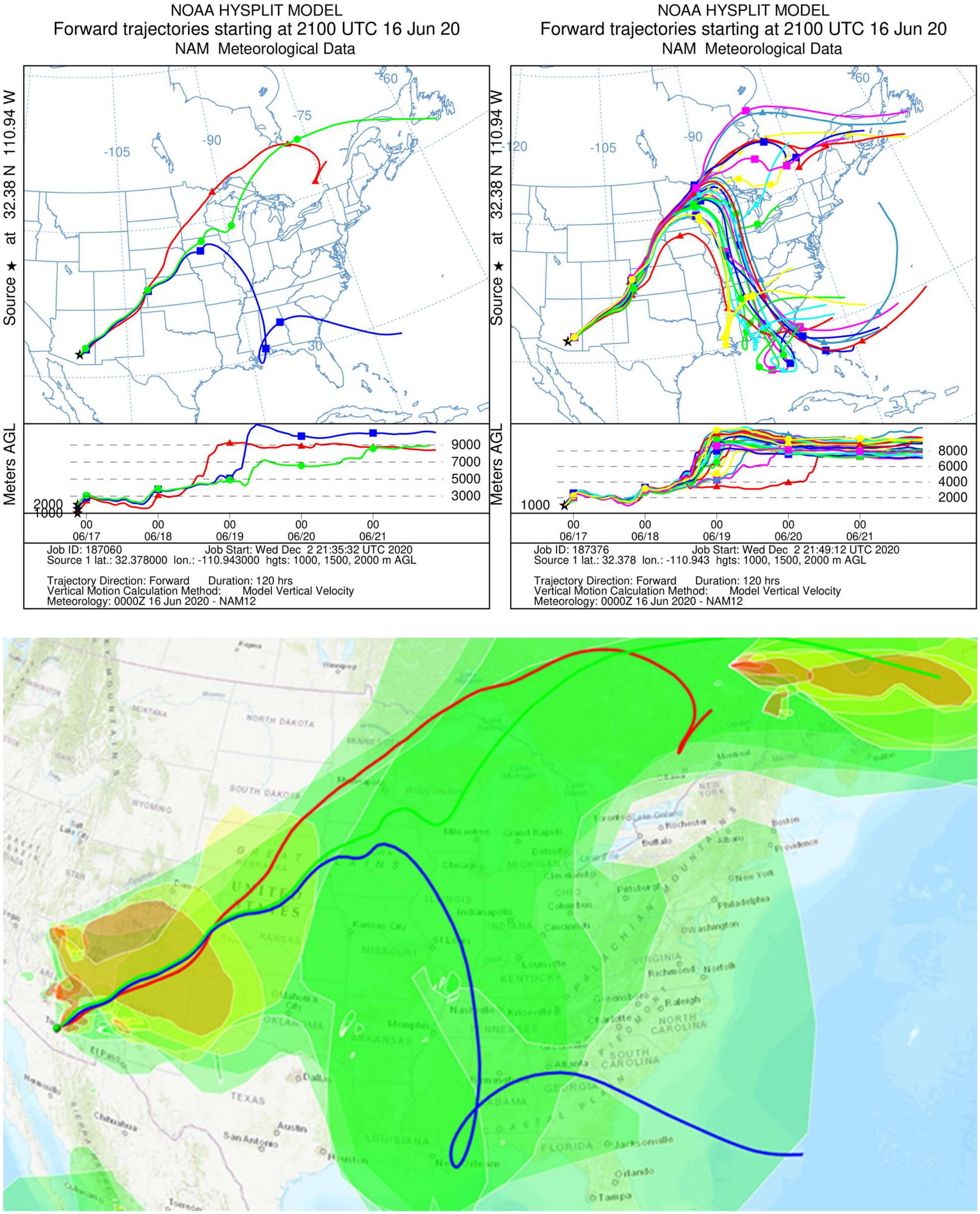

Figure 36. HYSPLIT 120-hour Forward Trajectory (top left), Forward Trajectory Ensemble (top right), and Forward Trajectory with HMS Smoke Overlay (June 19, 2020) (bottom) from Bighorn Fire June 16-21, 2020

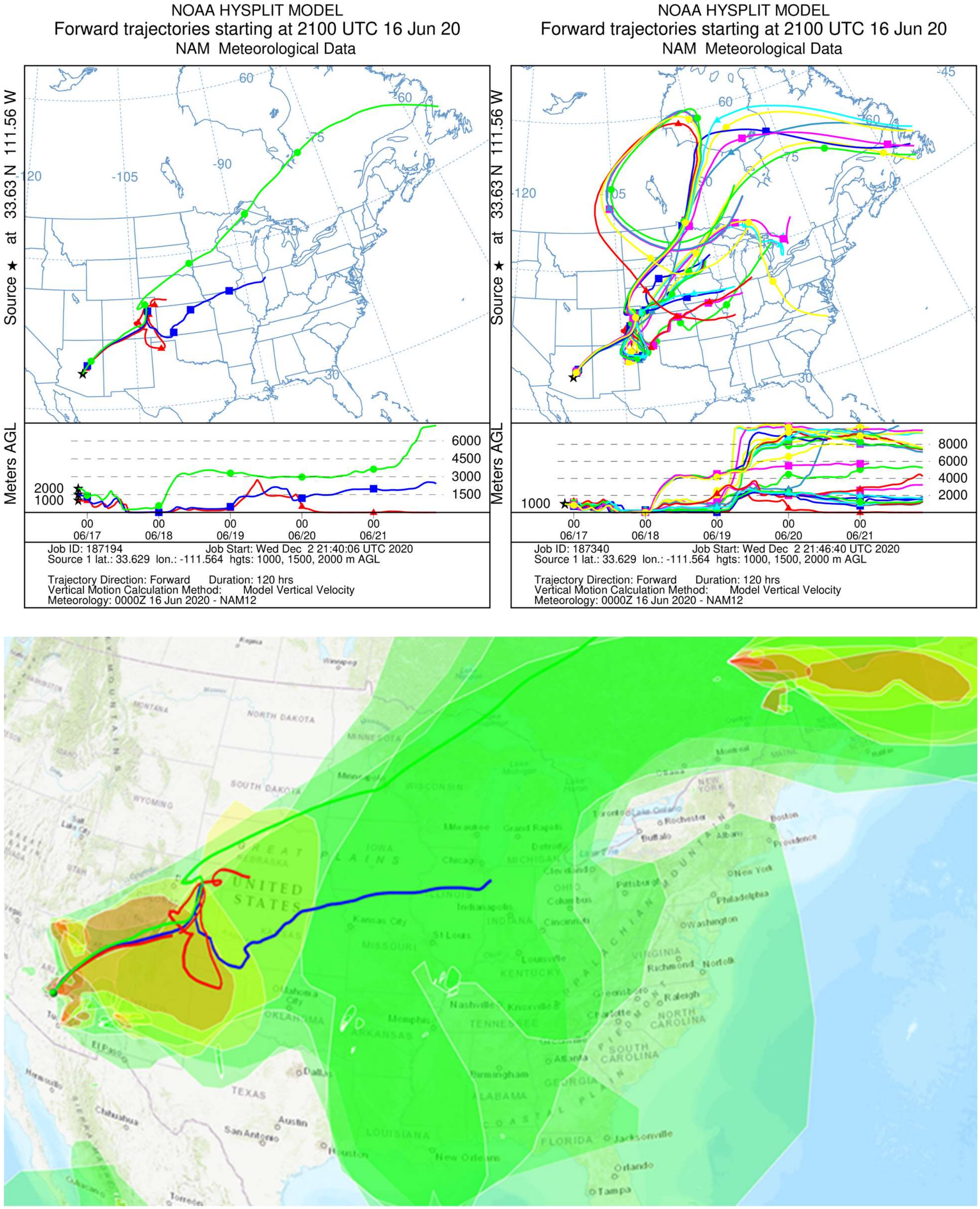

Figure 37. HYSPLIT 120-hour Forward Trajectory (top left), Forward Trajectory Ensemble (top right), and Forward Trajectory with HMS Smoke Overlay (June 19, 2020) (bottom) from Bush Fire June 16-21, 2020

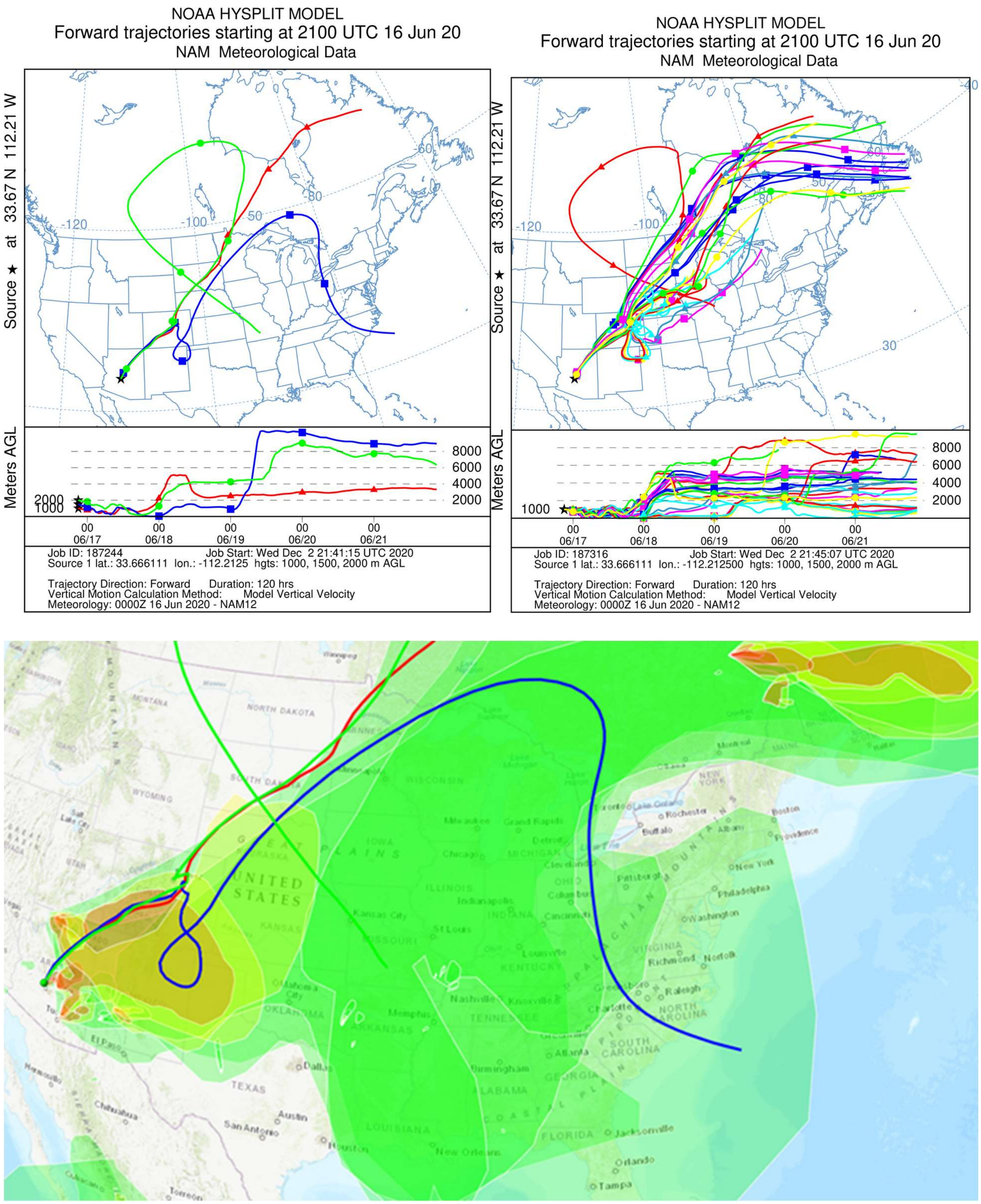

Figure 38. HYSPLIT 120-hour Forward Trajectory (top left), Forward Trajectory Ensemble (top right), and Forward Trajectory with HMS Smoke Overlay (June 19, 2020) (bottom) from Mangum Fire June 16-21, 2020

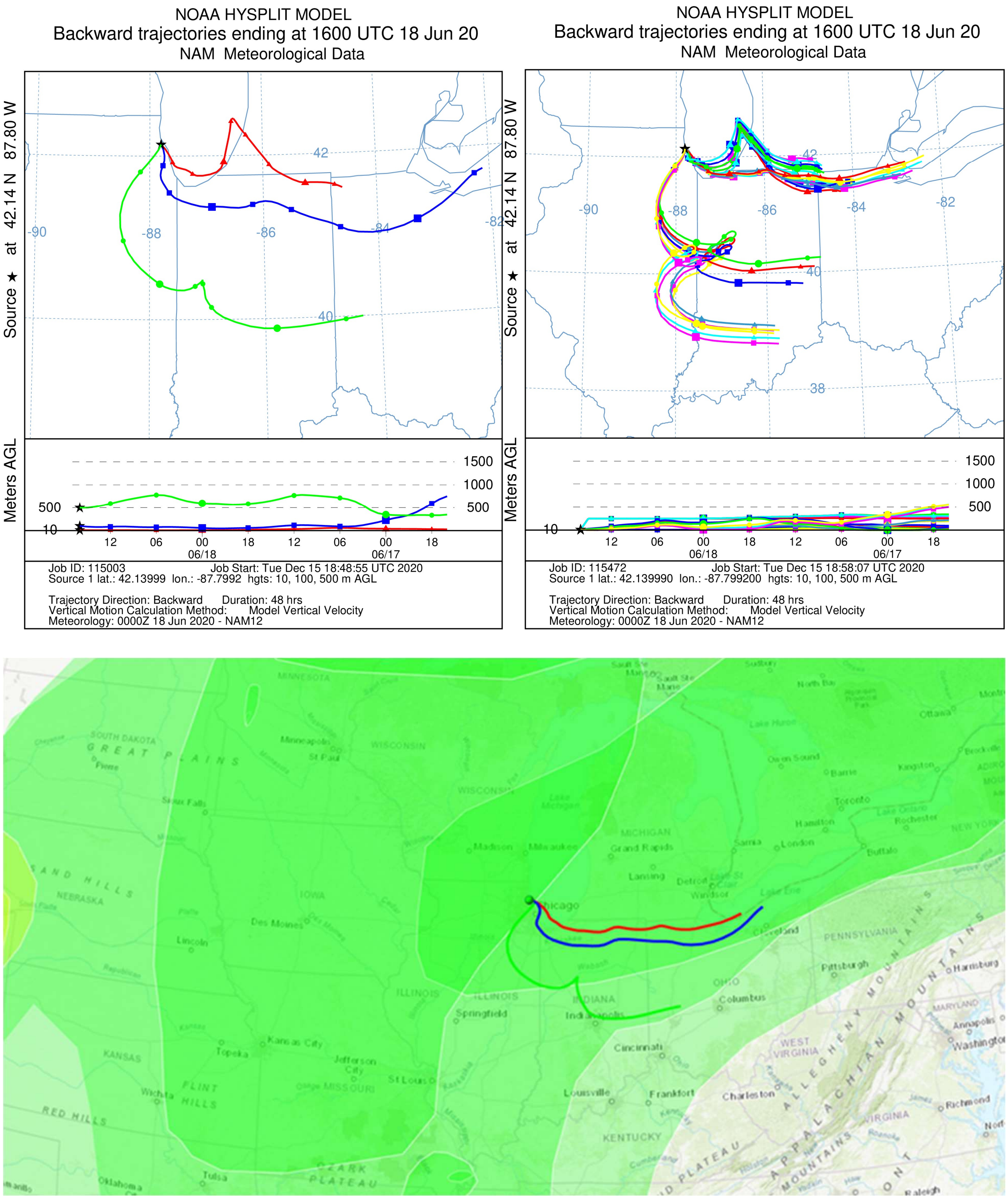

Figure 39. HYSPLIT 48-Hour Backward Trajectory (top left), Backward Trajectory Ensemble (top right), and Backward Trajectory with HMS Smoke Overlay (June 16, 2020) (bottom) from Northbrook Monitor June 18, 2020.

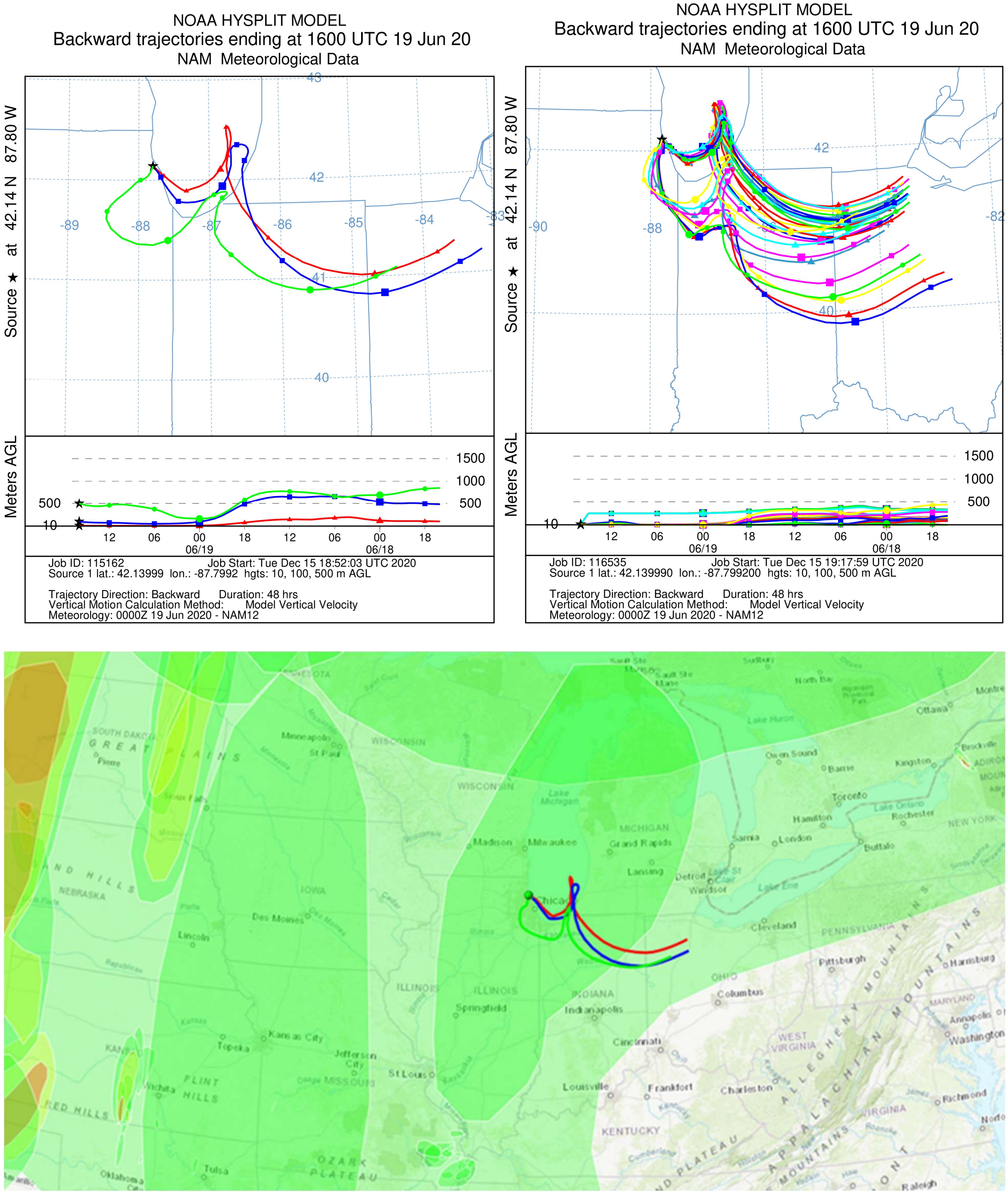

Figure 40. HYSPLIT 48-Hour Backward Trajectory (top left), Backward Trajectory Ensemble (top right), and Backward Trajectory with HMS Smoke Overlay (June 17, 2020) (bottom) from Northbrook Monitor June 19, 2020.

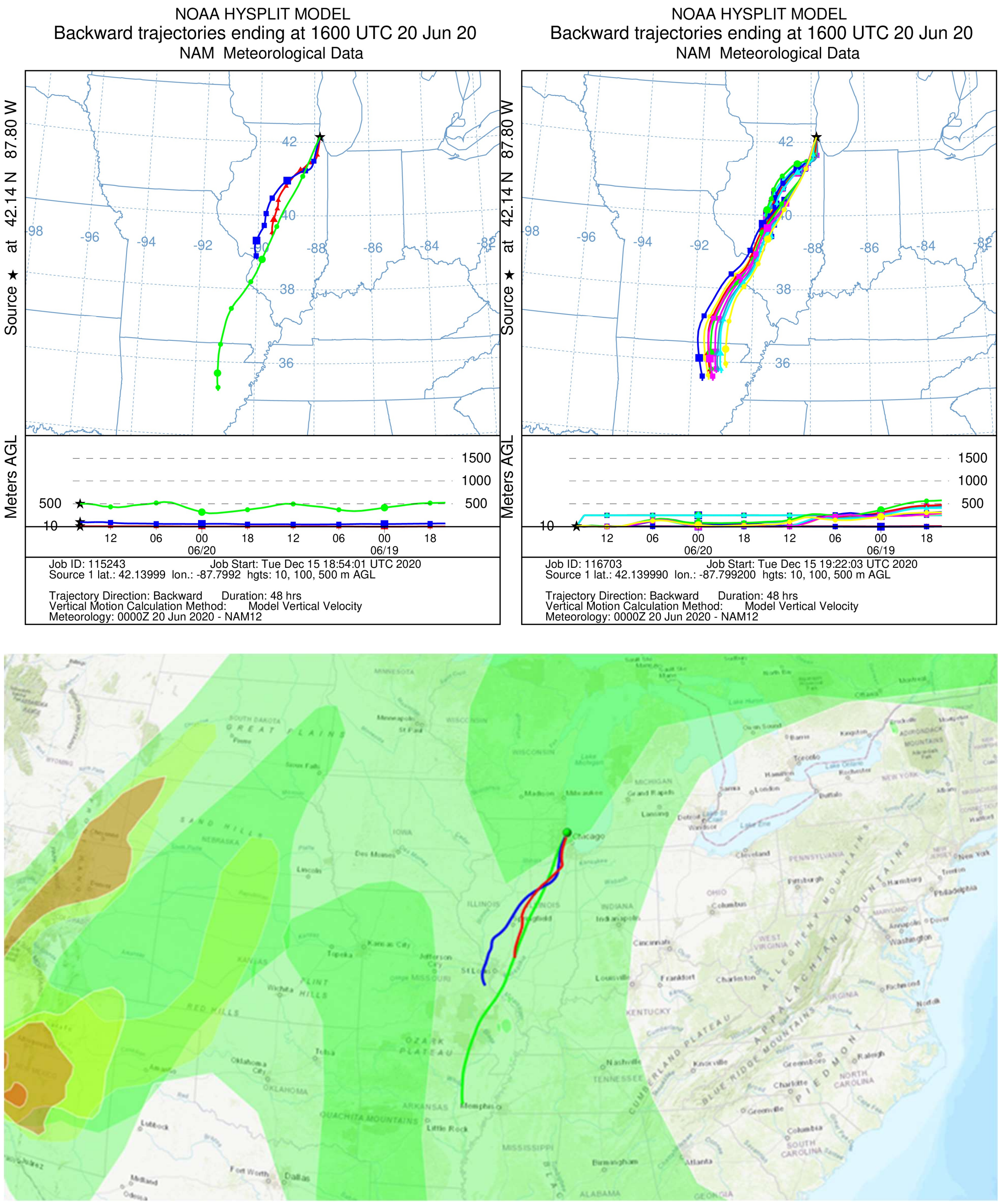

Figure 41. HYSPLIT 48-Hour Backward Trajectory (top left), Backward Trajectory Ensemble (top right), and Backward Trajectory with HMS Smoke Overlay (June 18, 2020) (bottom) from Northbrook Monitor June 20, 2020.

Aerosol Optical Depth, CO, and NO_2 Column Retrievals

Observational data which show the elevated presence of aerosols and gases in the Lake Michigan area on June 18 and 19, 2020, also support smoke transport from the Arizona wildfire complexes to the Northbrook monitor. Aerosols are particles in the air which scatter and absorb sunlight. Sources of aerosols include pollution from factories, smoke from fires, dust from dust storms, sea salt, volcanic ash, and smog. Aerosol optical depth (AOD) indicates the degree to which particles in the air (aerosols) prevent light from traveling through the atmosphere. Examining maps of AOD from the MODIS instrument onboard the Aqua and Terra satellites and the Suomi National Polar-orbiting Partnership (NPP) provides evidence to support the transport of smoke from fires in Arizona to the Lake Michigan region, as already demonstrated with visual imagery and trajectories. Figure 41 shows the MODIS combined value-added AOD for June 18, 2020. High AOD values between the Arizona wildfires (red circle) and smoke plume (blue circle) along the transport path to the upper Midwest are evident.

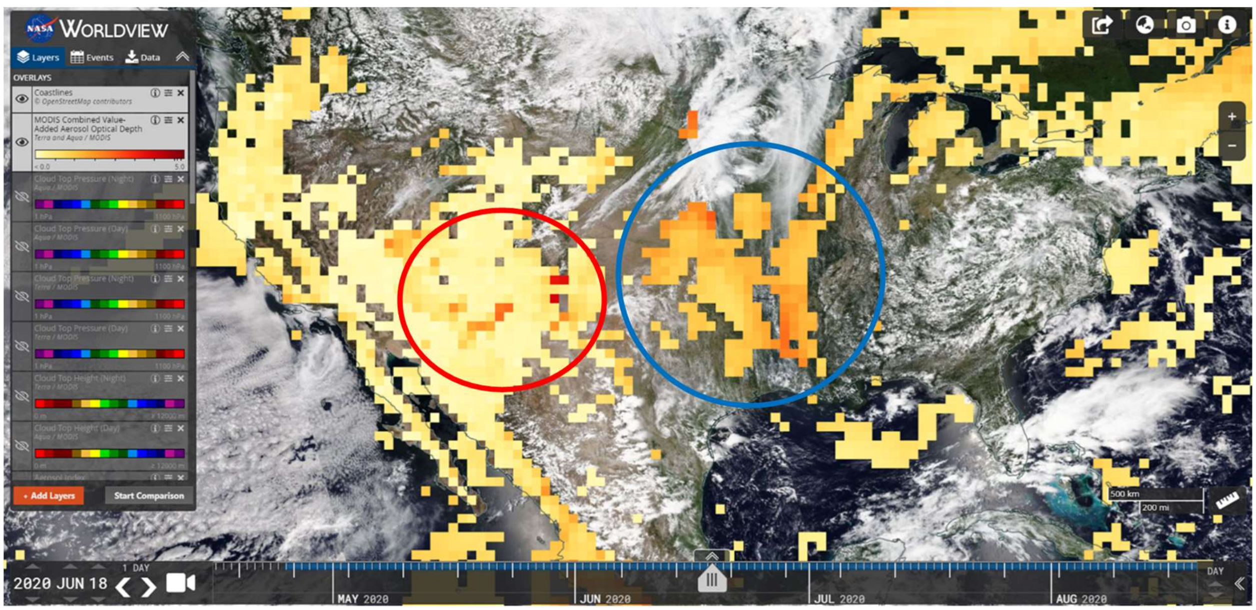

Figure 42. MODIS combined value-added AOD for June 18, 2020

Figure 42 presents the Suomi NPP AOD[31] for June 19, 2020. This figure shows high aerosol scatter around the Arizona fire locations (red circle) and in the Chicago region (green circle) associated with the smoke that has made its way into the airshed.

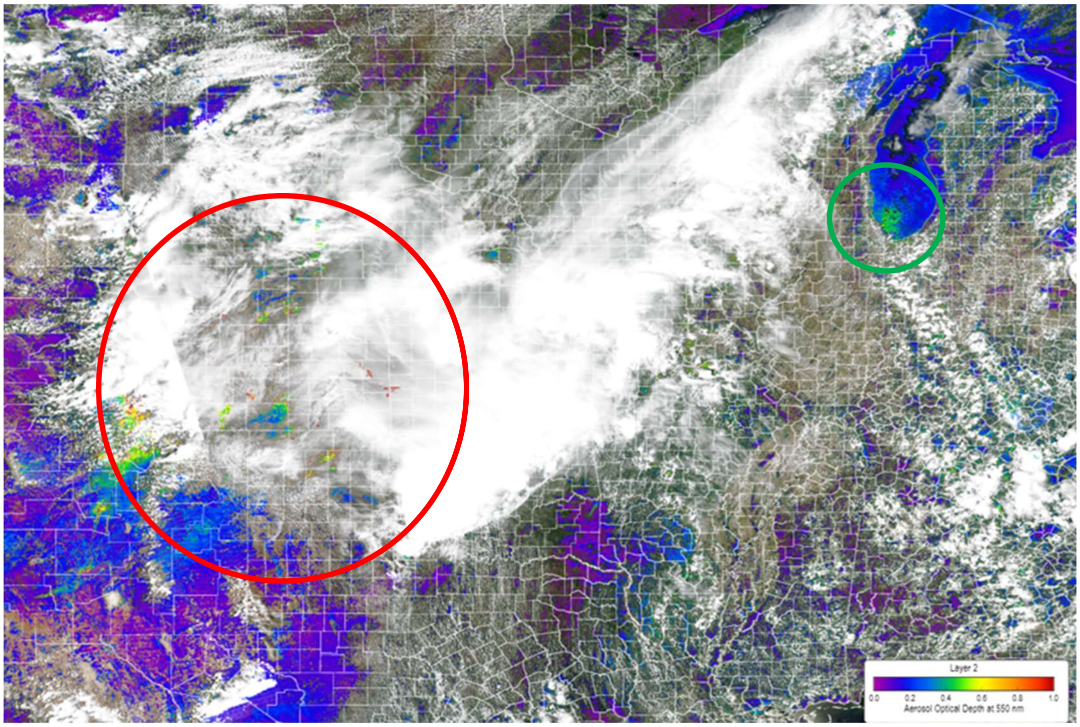

Figure 43. Suomi NPP AOD for June 19, 2020

The images show relatively high AOD on these days and provide further evidence that the smoke plume and associated ozone and PM2.5 precursors were present in the smoke plume and in the upper Midwest region in the days leading up to the exceedances, and during the exceedances in Chicago on June 18 and 19, 2020.

CO retrievals from the Atmospheric Infrared Sounder (AIRS) instrument onboard the Aqua satellite, and NO_2 retrievals from the Ozone Monitoring Instrument (OMI) were also examined. These maps indicate the presence of both gases and provide additional evidence to support the transport of smoke from fires in Arizona to the Lake Michigan region, as already demonstrated with visual imagery and trajectories described earlier.

[31] https://www.star.nesdis.noaa.gov/

CO measurements from AIRS show the same pattern of smoke plume transport seen in the MODIS AOD data noted above. The maps show smoke transport from the south and southwest through the southern and central United States and into the Lake Michigan region between June 18 and June 19, 2020. The high concentration of CO (red), indicating a smoke plume, over northern New Mexico on June 18 (Figure 43) is particularly clear in this imagery. By June 19, the CO plume has been transported northeast with the strongest signal still in Kansas and Oklahoma (Figure 44) with a signature of smoke present in the Mississippi Valley moving northward.

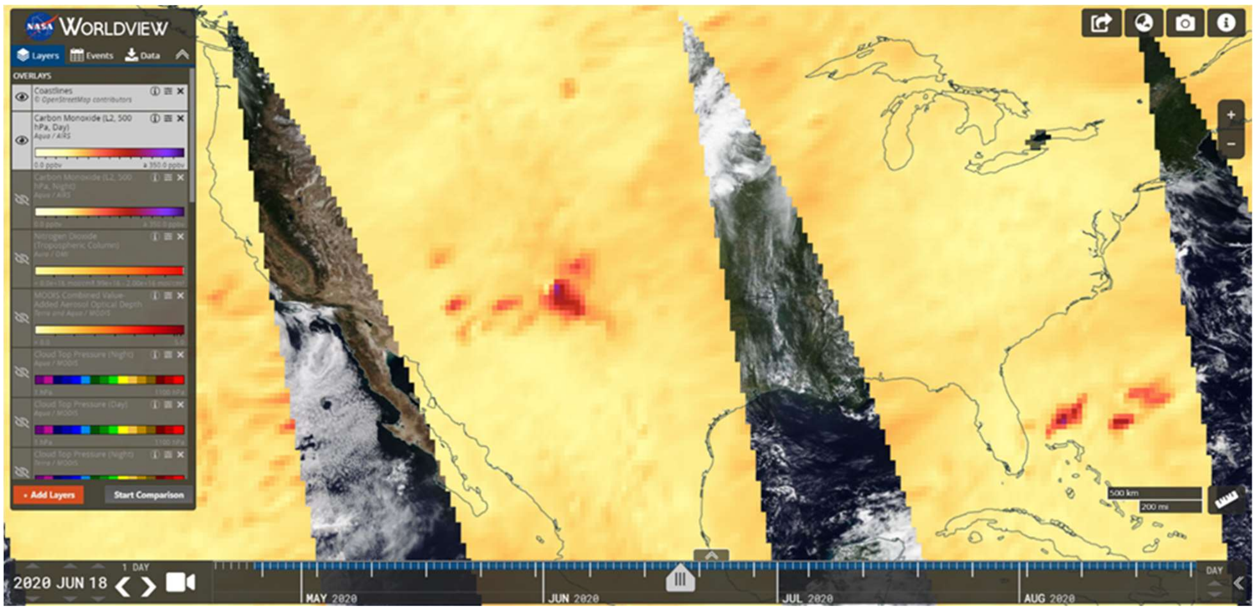

Figure 44. Aqua/AIRS CO Measurement for June 18, 2020

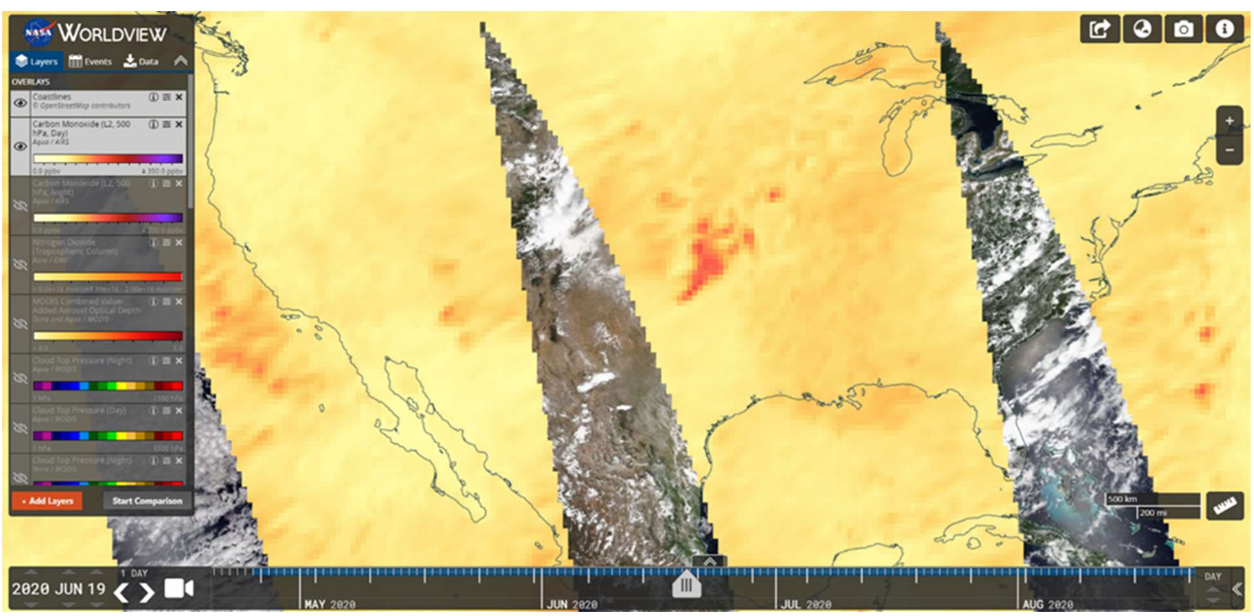

Figure 45. Aqua/AIRS CO Measurement for June 19, 2020

Additionally, OMI retrievals of tropospheric NO_2 (Figure 45) were examined. However, the retrievals likely reflect urban sources rather than NO_2 from smoke. Even over areas of dense, visible smoke and near actively burning fires (red circle), where significant smoke is present in the troposphere, the measurements show little increase in measured NO_2. Therefore, it was determined that column NO_2 does not provide strong evidence for or against smoke impacts in Chicago.

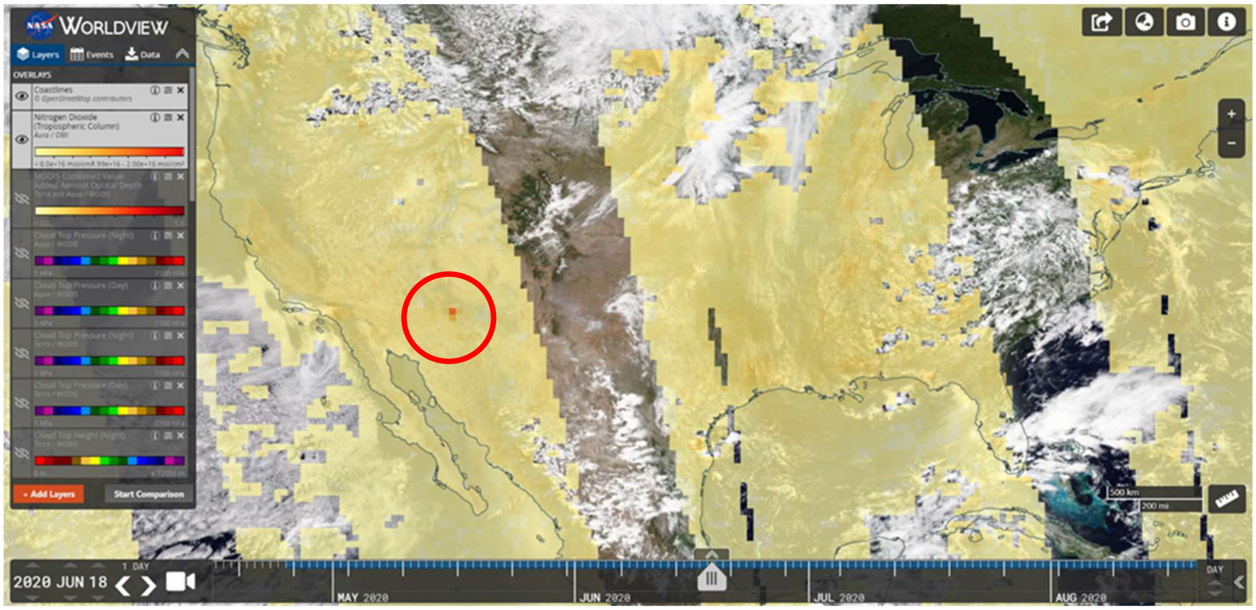

Figure 46. OMI Nitrogen Dioxide Tropospheric Column for June 18, 2020.

Evidence that the Fire Emissions Affected the Northbrook Monitor

Multi-pollutant and alternate species corroboration

Illinois EPA's monitoring network observes both total PM2.5 mass and speciated compounds such as ionic potassium (K+) and organic carbon (OC), as well as other pollutants such as CO and elemental or black carbon (EC) which can act as tracers of wildfire emissions.

The hourly ozone and PM2.5 concentrations at the Northbrook monitor and NO_2 and CO at the Kingery Near Road #1 monitor (17-031-0119) in the Chicago area were examined. Both monitors are in the same urban area and monitor for multiple parameters. The Northbrook monitor does not monitor for NO_2 and does not have consistent measurements for CO in 2020 due to equipment problems that occurred at the time of this event, so the Kingery Near Road monitor is being used as a regional alternate. Although both monitors were affected by the event, the impact on the Kingery Near Road monitor was determined not to have regulatory significance. However, an analysis of the hourly ozone, PM2.5, CO, and NO_2 in the days around the event is illustrative of the impact to the monitors in the Chicago NAA.

Figure 46 shows a marked increase in PM2.5 on June 18 and 19, 2020, at the Northbrook monitor. As shown in Figure 47, the Kingery Near Road monitor experienced an increase in maximum daily 1-hour NO_2 in the days of the smoke impact event. An increase in CO at this same monitor (Figure 48) during the episode period of June 18 and 19, 2020, along with PM2.5 is indicative of the arrival of the smoke plume and associated ozone precursors.

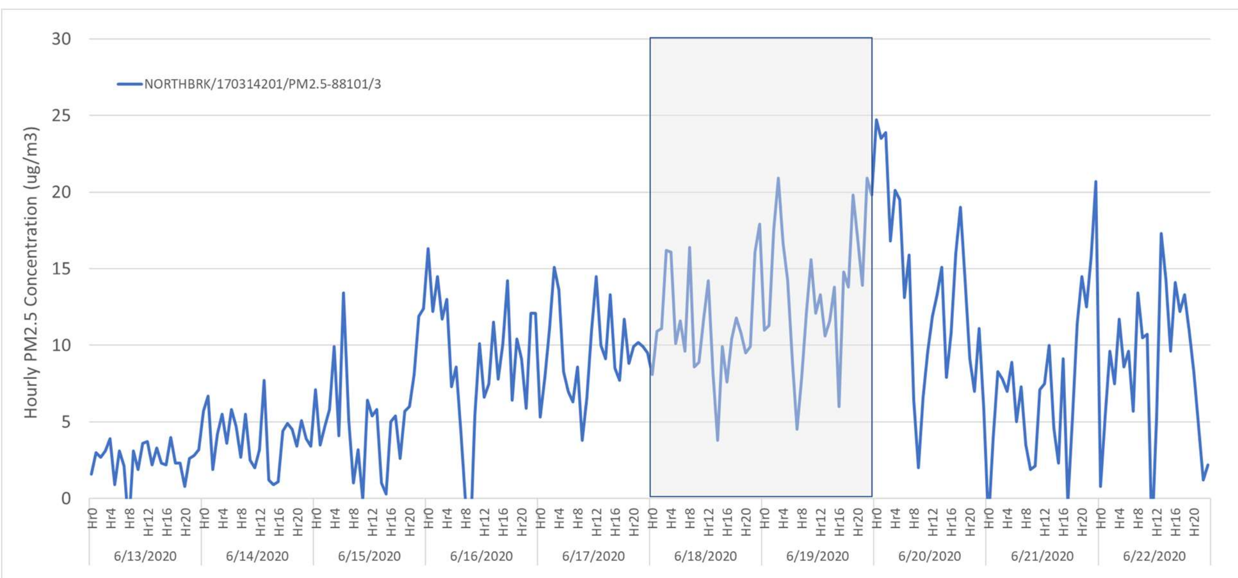

Figure 47. One-hour PM2.5 concentrations from June 13-22, 2020, at the Northbrook monitor.

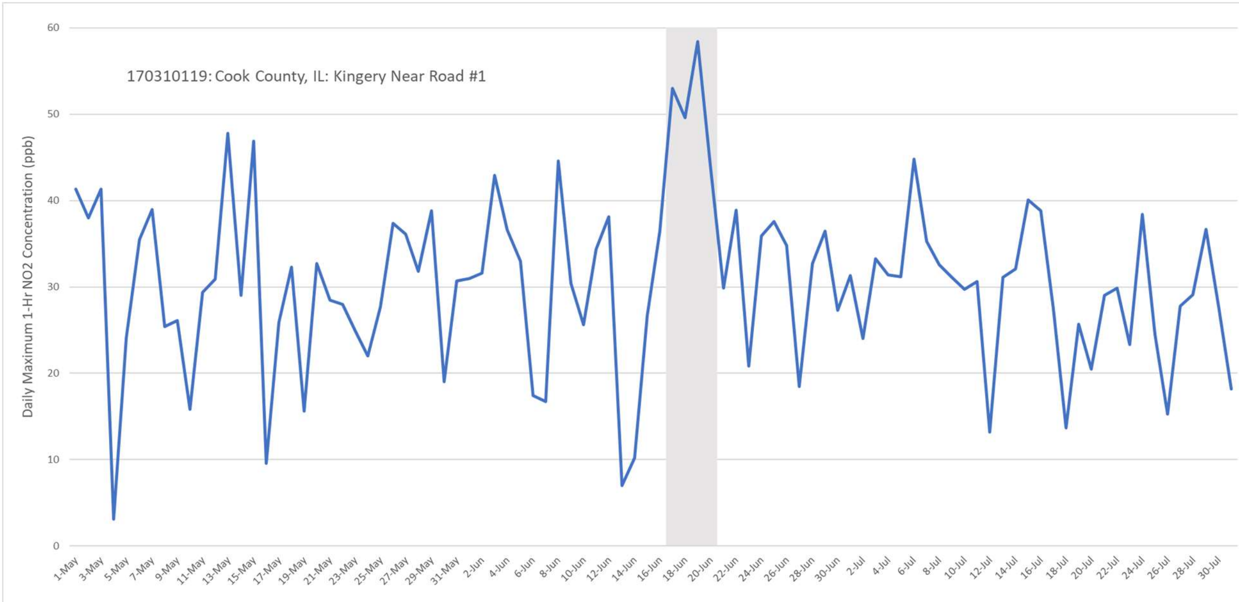

Figure 48. Daily Maximum 1-hr NO_2 concentrations from May 1 – July 30, 2020, at the Kingery Near Road monitor.

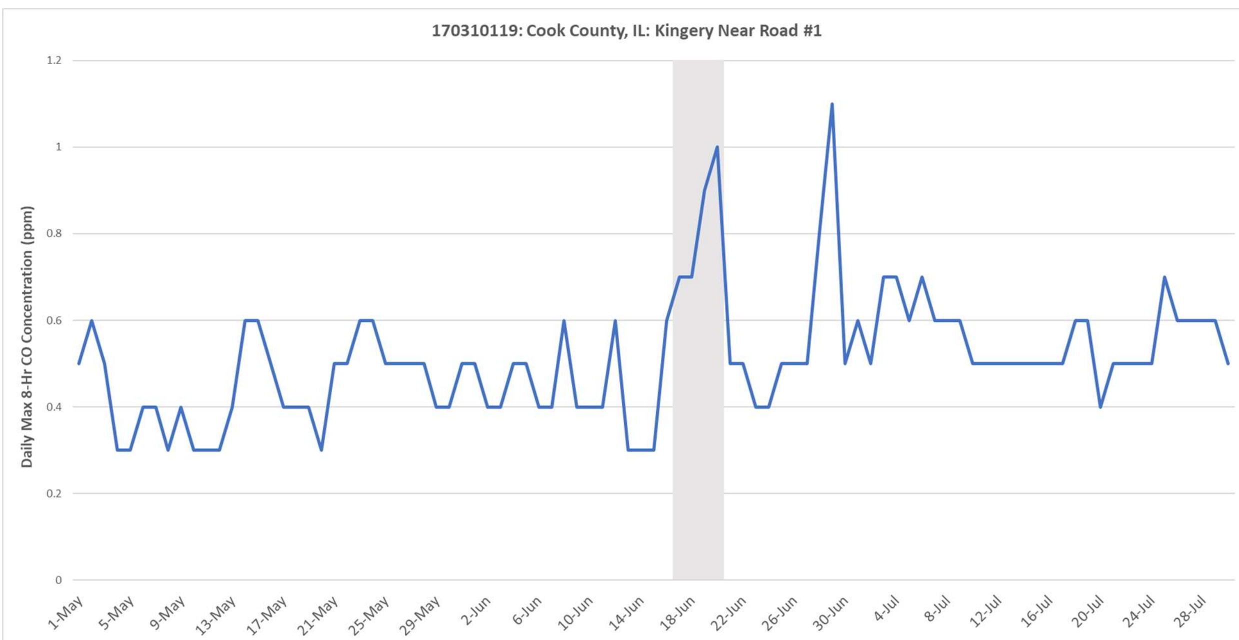

Figure 49. Daily Maximum 8-hr CO concentrations from May 1 – July 30, 2020, at the Kingery Near Road monitor.

OC and K+ are most associated with wildfire emissions, so comparing these chemical compounds against the monitored 8-hour maximums for these days can provide evidence regarding the impact of such emissions. Speciated data (run every 3 or 6 days) retrieved from the Northbrook monitor showed increased concentrations of both species on June 17 and 20, 2020, consistent with the track of the smoke plume analyzed by HMS and observed increases in the ozone concentrations. K+ acts as a useful tracer of wildfire smoke because there are few anthropogenic sources, and concentrations above background levels are a signature of wildfire emissions.[32]

Particularly on June 20, 2020, the magnitude of OC and K+ was largest at the monitor (except for July 5 observation associated with Independence Day fireworks), demonstrating influence by the wildfire smoke still present in the area. Since the K+ and OC are specific wood combustion markers, these speciated PM2.5 data provide conclusive evidence that the ozone affecting the airmass in Chicago developed in areas under the heavy influence of smoke related emissions.

Figures 49 and 50 show that K+, along with OC, increased around the time of the elevated ozone during the June 17-20, 2020, episode at the Northbrook Water Plant monitor, days in which smoke was visibly present over the location, providing further support that this was an event with a clear indicator of wildfire influence. This is also supported by an increase in EC as shown in Figure 51.

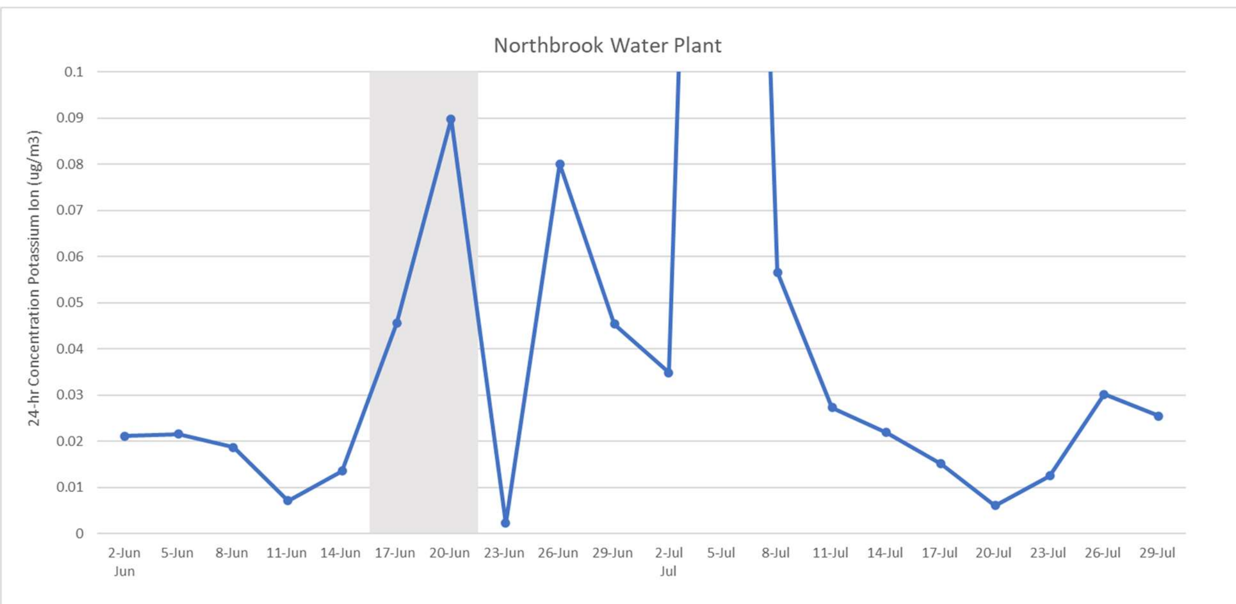

Figure 50. 24-hour K+ Concentration June and July 2020 at the Northbrook Water Plant Monitor. (July 5 observation associated with Independence Day Fireworks was 0.40 µg/m^3.)

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[32] Lee, T., A.P. Sullivan, L. Mack, J.L. Jimenez, S.M. Kreidenweis, T.B. Onasch, and D.R. Worsnop, Chemical smoke marker emissions during flaming and smoldering phases of laboratory open burning of wildland fuels. Aerosol Science and technology 44(9): i–v, 2010.

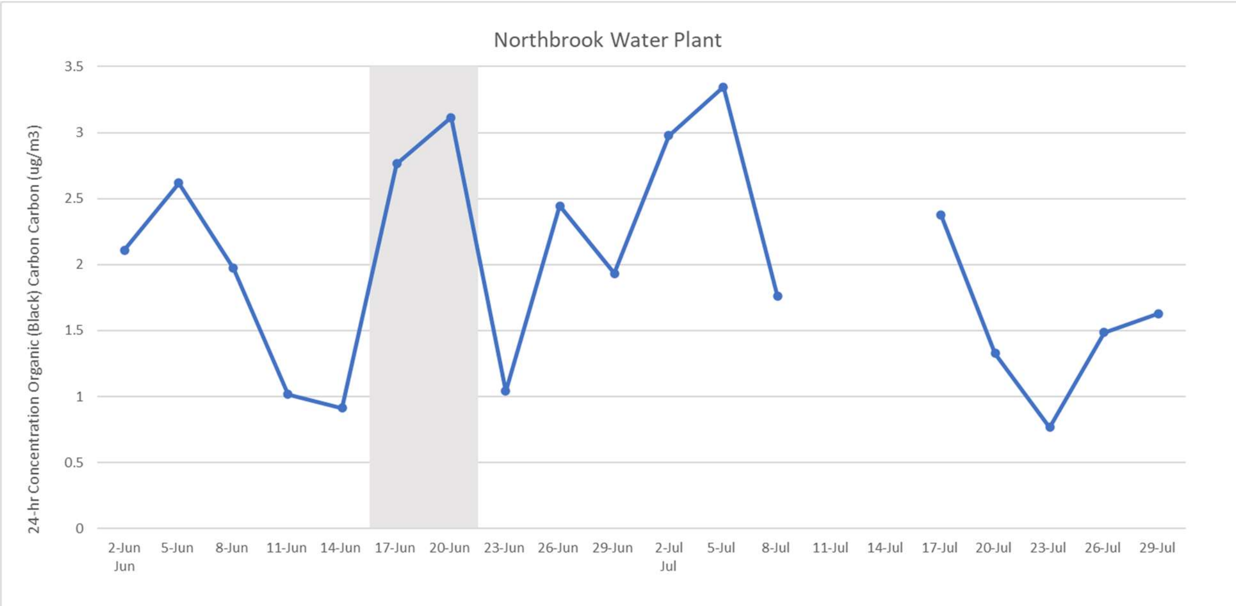

Figure 51. 24-hour OC Concentration June and July 2020 at the Northbrook Water Plant Monitor.

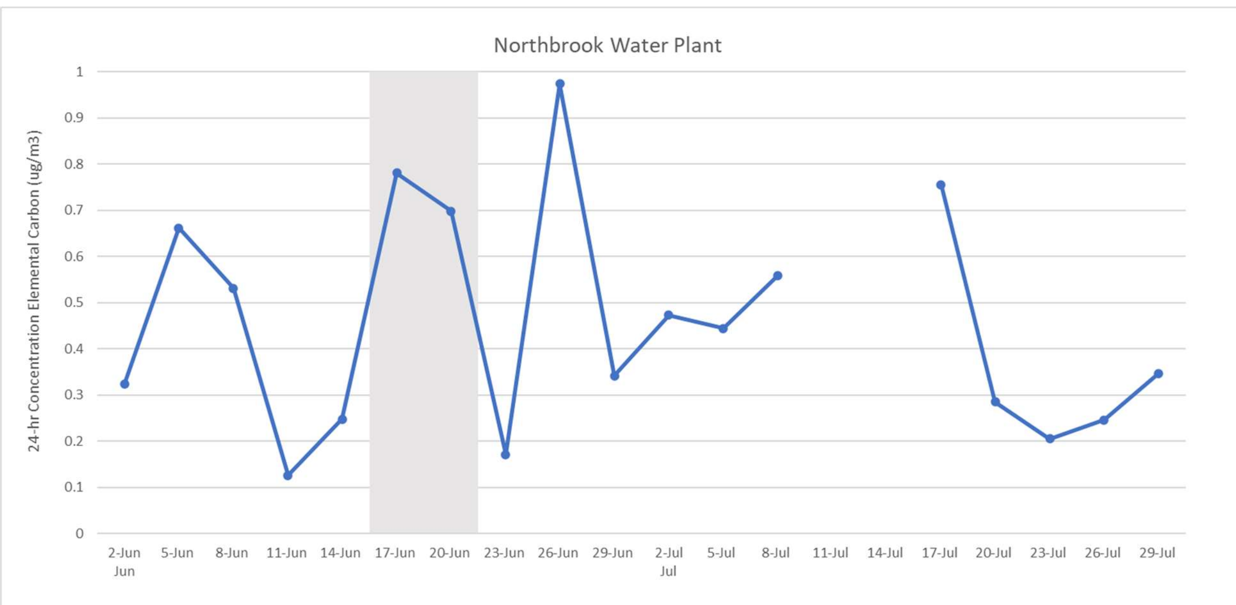

Figure 52. 24-hour EC Concentration June and July 2020 at the Northbrook Water Plant Monitor.

Additional Evidence that the Fire Emissions Caused the Ozone Exceedances

Similar Day Analysis

A similar day analysis is used to identify days which are similar in pattern and characteristics (temperatures, winds, transport regime) but are without the burden of smoke on ozone production. In a comparison of such days, affected monitors should show substantially less ozone when not impacted by smoke.

June 19, 2020, at the Northbrook Water Plant monitor was used as the target day. It was a clear, sunny day with a high temperature of 90 degrees Fahrenheit (F), calm to light surface winds from the southeast and upper air from the south-southwest. To isolate similar days within the past five years, a review was conducted of historical records[33] at the Northbrook location with days reaching at least 85 degrees F, wind speed less than 7.0 miles per hour, relative humidity between 85 and 92%, and wind direction out of the south-southeast (90 – 180 degrees). Wind speed and direction are not recorded at the Northbrook monitor so data from the Alsip monitor (17-031-0001) in Chicago were used.

While there have been exceedances of 75 ppb on other days in the recent past, none of these reviewed days with comparable meteorological conditions – but without the influence of smoke — (e.g., May 24-27, 2018, and July 13-15, 2018) have demonstrated ozone levels as high as that observed on June 18 or 19, 2020.

From the list of potential days, four were selected as having the closest comparison in each of meteorological parameters relative to June 19, 2020. A list of those days, their meteorological observations, and observed MDA8 ozone observations are presented in Table 6.

Table 6. Similar Day Analysis: Comparison of MDA8 Ozone Levels at Northbrook Monitor

Date	Max Temp (°F)	Wind Spd (Avg mph)	Wind Dir	Relative Humidity (%)	Pressure (mb)	MDA8 (ppb)
6/19/2020	90	3.8	SE	87	989	82
8/3/2016	85	3.2	SE	94	999	69
7/6/2017	89	5.4	SW	87	992	67
9/22/2017	92	5.1	SE	87	994	66
9/23/2017	88	3.7	SE	92	995	64

Figures 52-56 show 48-hour HYSPLIT back-trajectories along with combined daily ozone and PM2.5 AQI maps for June 19, 2020, and the comparison days of August 3, 2016, July 6, 2017, September 22, 2017, and September 23, 2017. Except for September 22, 2017, all comparison trajectories show the same general transport pattern of a loop around the southern shore of Lake Michigan and movement from over northern Indiana and Ohio, consistent with the June 19, 2020, pattern.

[33] https://aqs.epa.gov/aqsweb/airdata/download_files.html

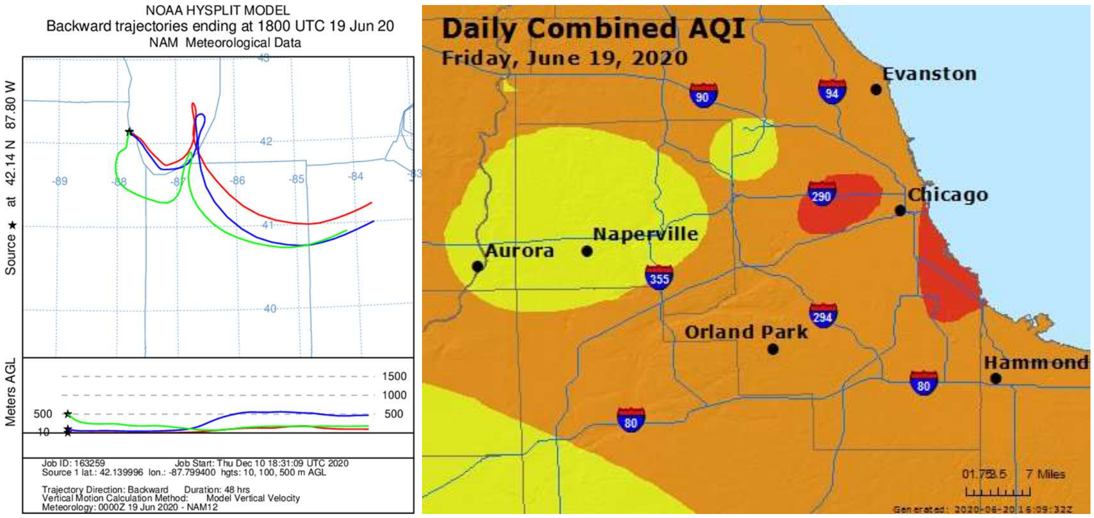

Figure 53. HYSPLIT back-trajectory (left) and Daily Ozone and PM2.5 AQI (right) for June 19, 2020

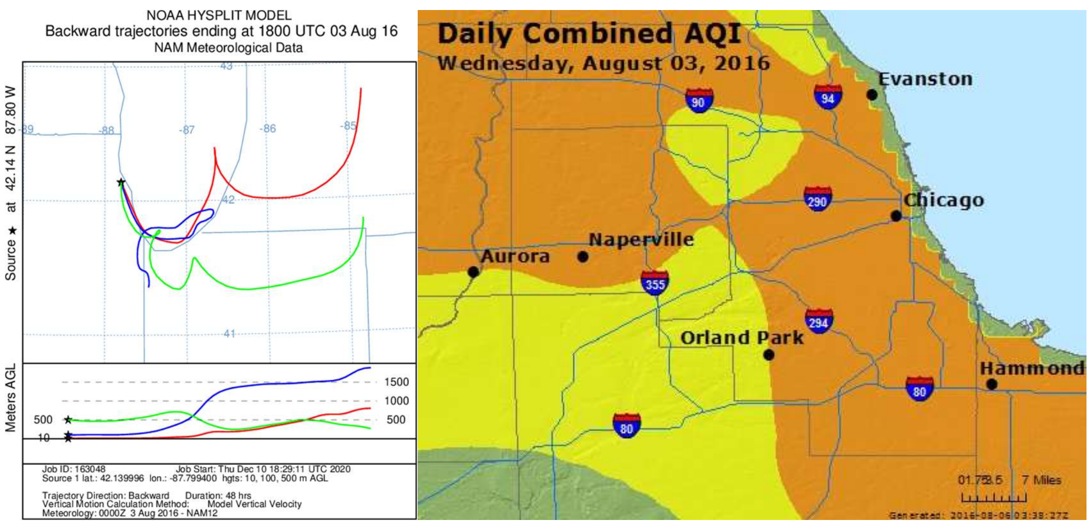

Figure 54. HYSPLIT back-trajectory (left) and Daily Ozone and PM2.5 AQI (right) for August 3, 2016

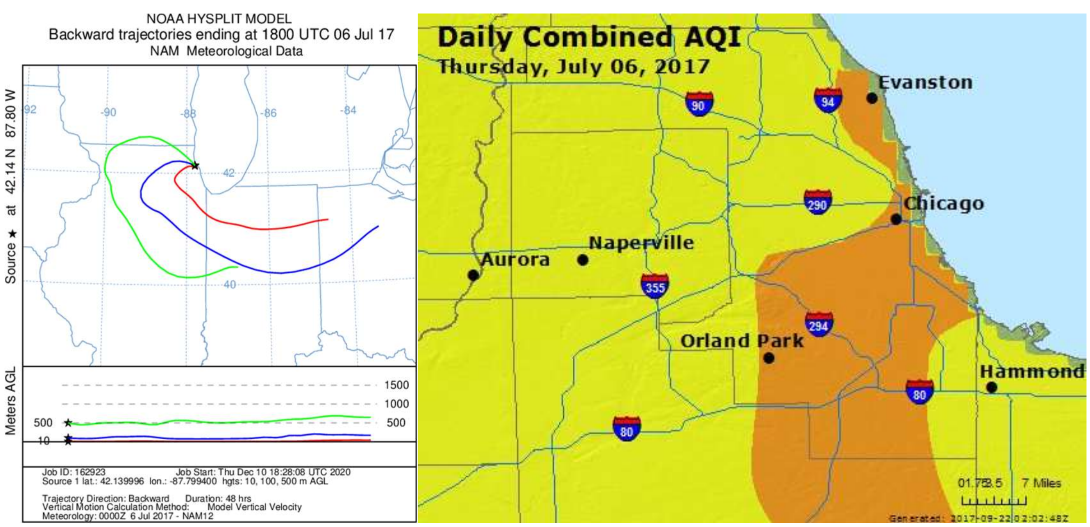

Figure 55. HYSPLIT back-trajectory (left) and Daily Ozone and PM2.5 AQI (right) for July 6, 2017

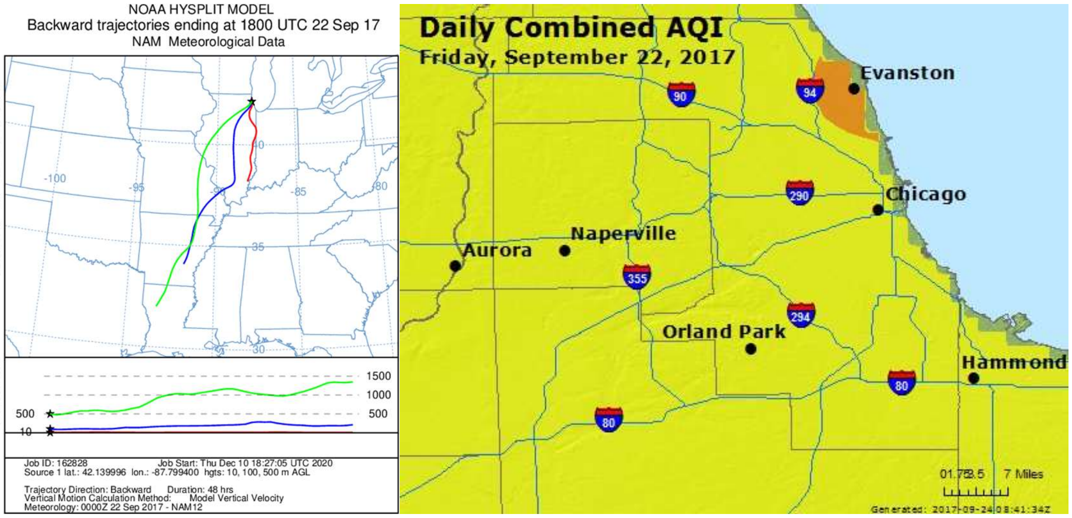

Figure 56. HYSPLIT back-trajectory (left) and Daily Ozone and PM2.5 AQI (right) for September 22, 2017

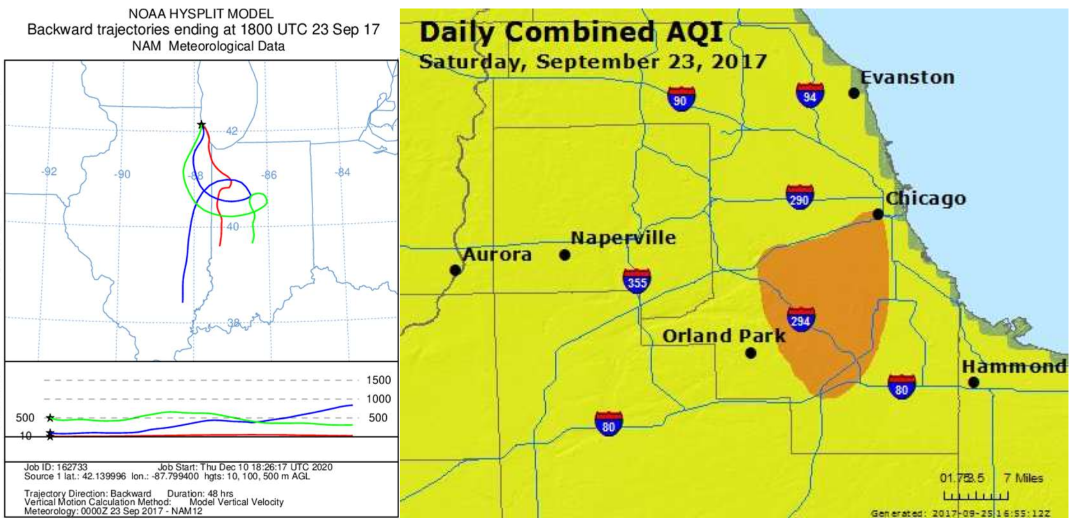

Figure 57. HYSPLIT back-trajectory (left) and Daily Ozone and PM2.5 AQI (right) for September 23, 2017

This evidence suggests the June 18 and 19, 2020, exceedance events were influenced by factors not explained by this similarity analysis, lending support to the conclusion that the influence of wildfire smoke created the ozone exceedances on those days.

Average Standardized Log-transformed Timeseries

LADCO developed a screening analysis that focused on finding signals in standard surface monitoring data to identify when there is potential for smoke influences on surface air quality conditions during the ozone season (April 1 – October 31). In this analysis, they looked at associations between Air Quality System (AQS) observations of MDA8 ozone, MDA8 CO, and Clean Air Status and Trends Network (CASTNet) daily average total PM2.5. The working hypothesis was that coincident peaks in all three of these pollutants may indicate smoke influence in a NAA.

LADCO developed ozone, PM2.5, and CO concentration anomaly plots to identify potential smoke enhancements to surface ozone within the Great Lakes region. The anomaly plots present time series of log-normalized, standardized measurements in units of standard deviation. LADCO identifies periods with all three pollutants above one standard deviation of the five-year average monthly mean as being impacted by smoke.

The anomalies are derived from five-year averages of monthly average measurements from multiple sites within a NAA (e.g., the five-year average of the June monthly average concentrations). The ambient concentration data are log normalized to transform them to a normal distribution. Normalizing the distributions of the data allows for the inter-comparison across the three pollutants. The data are standardized to both support the inter-comparison between pollutants, and to attenuate the inter-annual variability in the data.

A factor in the standardization method is to divide by the five-year monthly standard deviation for each pollutant. By dividing a measurement for a given day by the five-year standard deviation for that same month, this metric normalizes the measurement to account for 68% of the variability in the data, which includes meteorological differences. Standardizing with the monthly five-year standard deviation, rather than the entire ozone season five-year year standard deviation, further attenuates the impacts of longer term, seasonal variability in the meteorology.

LADCO first applied the hypothesis as a proof of concept to the May 2016 Fort McMurray fire and its impact on monitors in the Cleveland, Ohio, region. Figure 57 shows ozone (red), CO (green), and PM2.5 (blue) concentration anomalies using the LADCO concentration anomaly plot for the Cleveland NAA in 2016. Grey bars indicate days when smoke was present in the region. Ozone is above two standard deviations for the May 2016 episode, CO and PM2.5 are up above one standard deviation, with some monitors exceeding 1.5 standard deviations. Standardization (i.e., normalization) was done using the monthly mean and standard deviation of the log-transformed observed values at each site within the region over a historical period (Figure 58).

U.S. EPA concurred[34] with an exceptional event demonstration by Ohio EPA that the May 24-25, 2016, Cleveland ozone episode was impacted by wildfire smoke from the Ft. McMurray fire in Western Canada. These figures show the ozone, PM2.5, and CO concentration anomalies during May 24-25, and illustrates that this metric is useful for identifying when ozone is enhanced by wildfire smoke.

[34] https://www.epa.state.oh.us/portals/27/SIP/ozone/USEPA_Letter_3-18-19.pdf

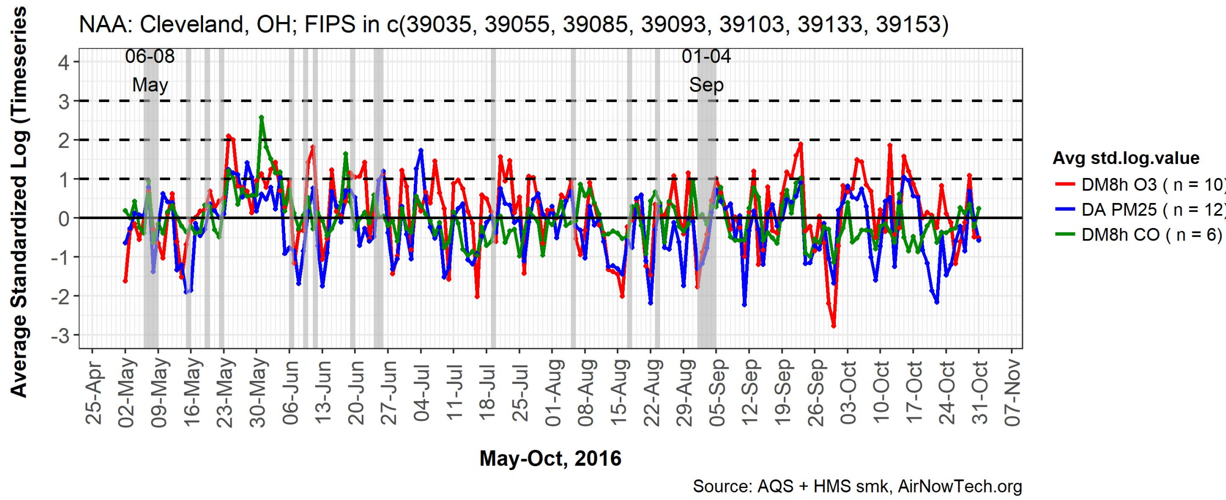

Figure 58. Average anomaly plots for the Standardized Log Timeseries of daily maximum 8-hour ozone, and daily average 24-hour PM2.5, and daily maximum 8-hour CO concentrations measured from the Cleveland NAA Monitors based on historical Ozone Season Concentrations.

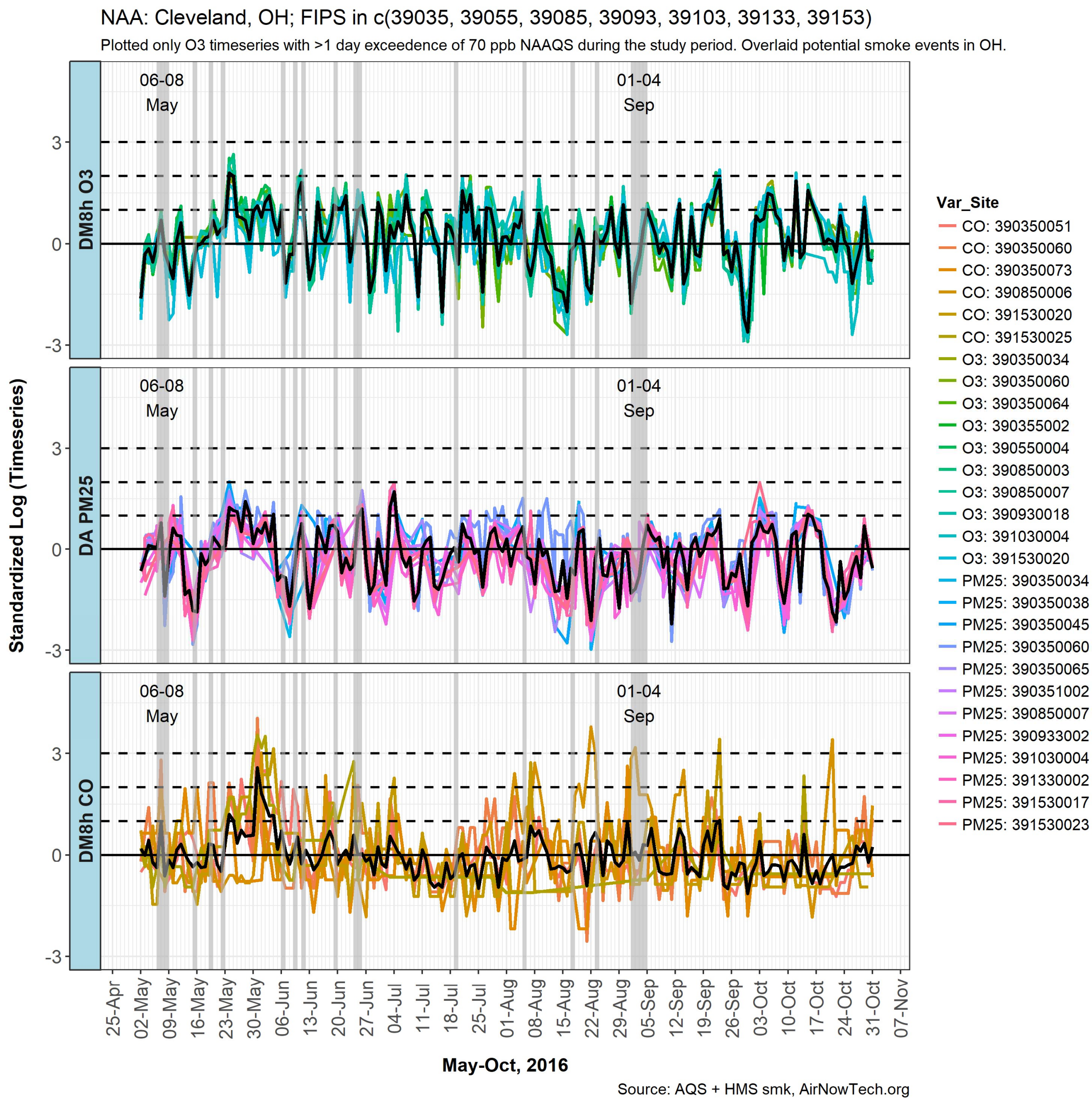

Figure 59. Site-specific daily maximum 8-hour ozone, daily average PM2.5, and daily maximum 8-hour CO concentration anomalies in the Cleveland NAA, shown by standardized log-transformed time series w.r.t. monthly mean and standard deviation values in the 2013-2017 period.

The Chicago NAA anomaly plot in Figure 59 shows a similar anomaly for the June 18-19, 2020, period. The CO and PM2.5 anomalies both exceed 1.5 standard deviations and are even more pronounced for this event than for the Ft. McMurray fire in Cleveland.

Figure 59 below is an average standardized log-transformed timeseries plot that shows ozone, CO, and PM2.5 concentration anomalies for the Chicago NAA during the 2020 ozone season. This plot summarizes a separate monitor-specific plot (Figure 60) and was created by averaging the standardized timeseries across all monitors within the NAA. The monitor-specific standardized log-transformed timeseries plot shows ozone (red), CO (green), and PM2.5 (blue) concentration anomalies at individual monitors in the NAA during the 2020 ozone season (Figure 60). Again, grey bars indicate that smoke was present in the region and asterisks denote days when ozone exceeded the level of the NAAQS. Standardization (i.e., normalization) was done using the monthly mean and standard deviation of the log-transformed observed values at each site over the 2016-2020 period.

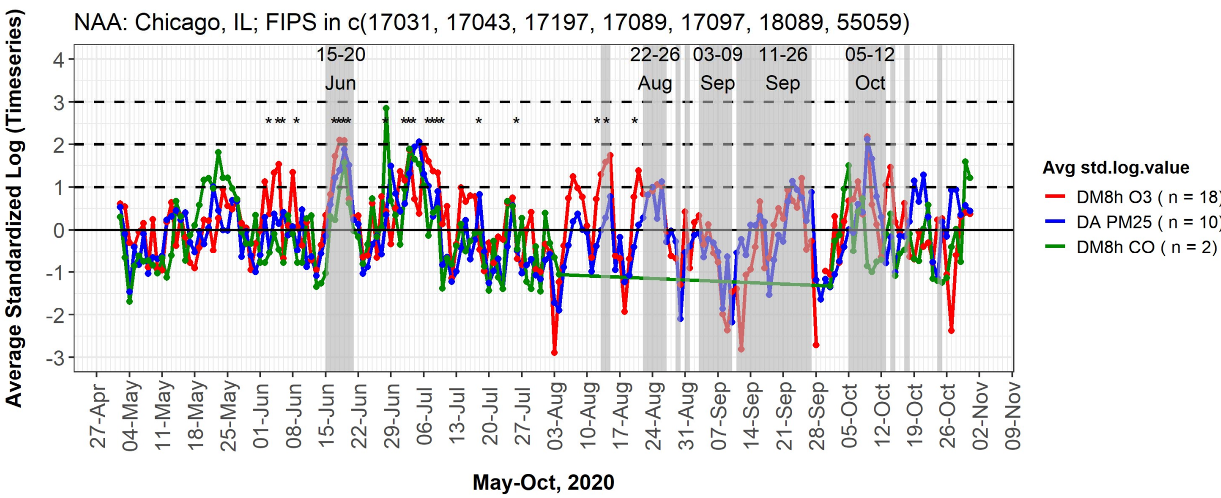

Figure 60. Average anomaly plots for the daily maximum 8-hour ozone, daily average PM2.5, and daily maximum 8-hour CO concentrations measured in the Chicago NAA.

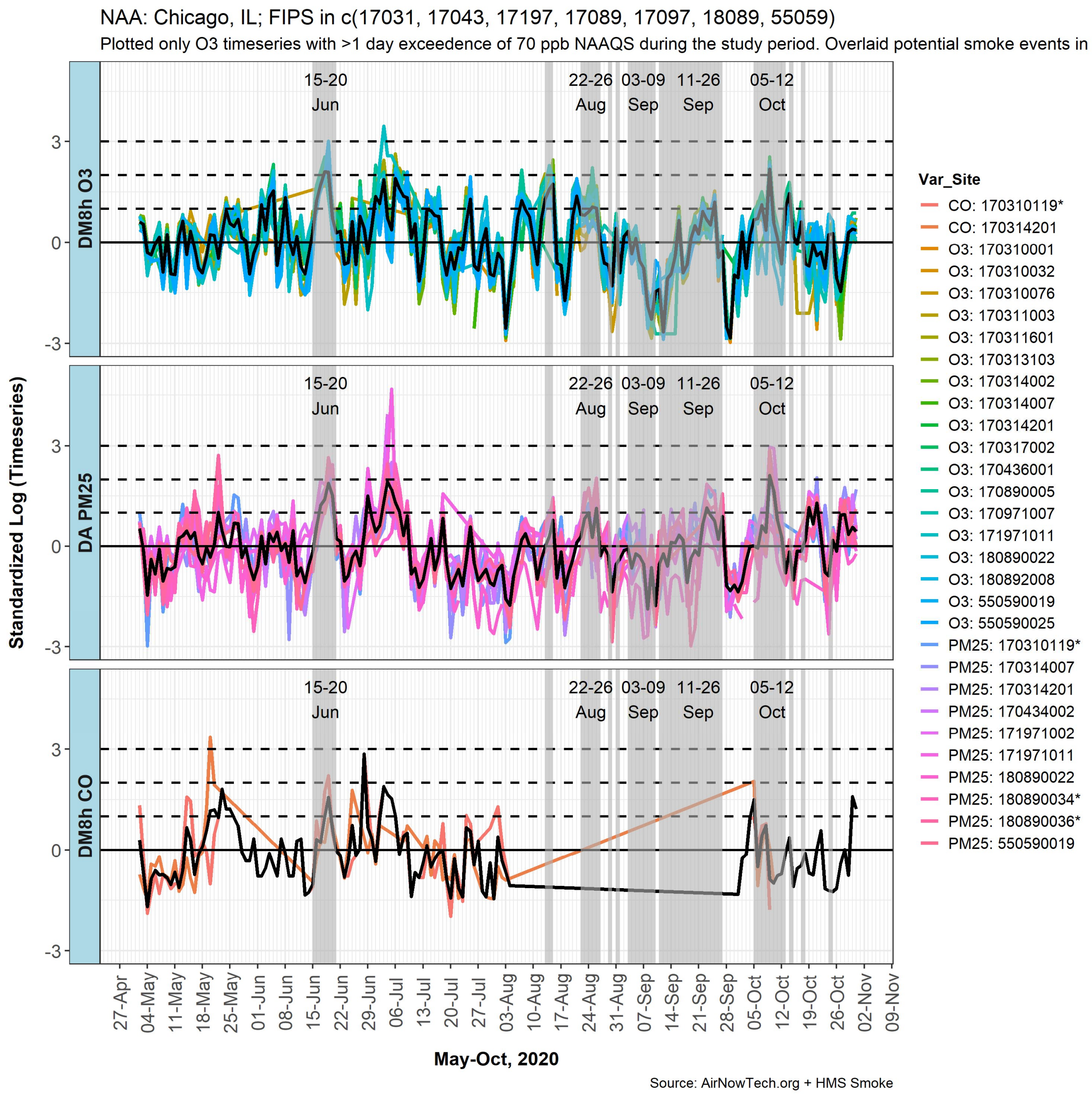

Figure 61. Daily maximum 8-hour ozone, daily average PM2.5, and daily maximum 8-hour CO concentration anomalies at each site in the Cleveland NAA, shown by standardized log-transformed time series w.r.t. monthly mean and standard deviation values in the 2013-2017 period.

As can be seen in both figures, the period of June 17 through June 20, 2020, shows anomalous concentrations compared to the log normalized remainder of the ozone season. This is an indicator that smoke was present and enhanced the ozone concentrations on those days.

An additional average normalized log-transformed analysis was conducted on the Northbrook monitor using the ozone season mean and standard deviation of the log-transformed observe values at the site for each year of 2018, 2019, and 2020. These plots are also designed to show ozone, CO, and PM2.5 anomalies for the NAA in these three years. The plots were created by averaging the standardized timeseries concentrations across all the monitors in the NAA. Figure 61 is the product of this analysis for the Northbrook monitor and presents the top ten observed ozone days for each of the years 2018, 2019, and 2020. The days are presented in decreasing order (left to right) from highest observation to lowest within a year. A grey column overlay indicates that there is also HMS smoke present over the monitor on the noted day.

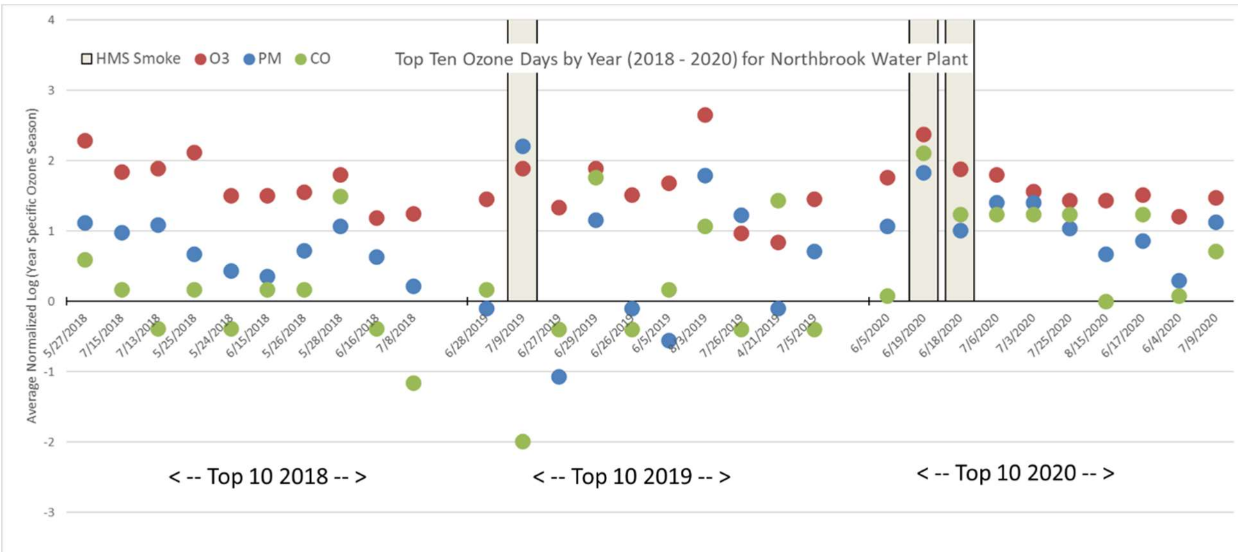

Figure 62. Average normalized log timeseries of the top ten ozone days by year (2018-2020) at the Northbrook monitor for ozone, PM2.5, and CO.

As seen in Figure 61, if all three calculated values (represented as dots) demonstrate a higher average normalized log value, this is an indication that smoke was present and enhanced the ozone concentrations on those days. In looking at the right side of the figure, we see that June 17, June 18, and June 19 are among the days with high ozone, PM, and CO values and where the HMS smoke product indicates the presence of smoke.

D. Conclusion - Clear Causal Relationship

Three large wildfires in Arizona were identified that were part of the largest wildfire season the state had on record, where over 955,000 acres burned through November 2020. From the three fires - the Bush, Mangum, and Bighorn wildfires - close to 385,000 acres burned between June 5 and July 27, 2020, on Arizona wildlands generating ozone, PM2.5, and their precursors. These wildfires emitted a large plume of smoke that was visible in satellite images and measurements. The transport of these pollutants within the plume resulted in elevated concentrations at the Northbrook Water Plant monitor (17-031-4201) in the Chicago 2008 Ozone NAA on June 18 and 19, 2020. The monitored ozone concentrations were unusually high, especially given recent trends. Both instances for which ozone data exclusion is requested were among the four highest ozone concentrations in 2020 and were above the 99th percentile among data from 2016 to 2020.

Although the meteorological conditions that existed during the event could have potentially caused elevated ozone at usual summer season levels without the increased burden of the additional wildfire-related precursor emissions, the influence of the Arizona wildfire smoke plume emissions caused significant additional impact that elevated ozone levels beyond normal expectations. As the smoke plume aged and mixed with anthropogenic NOx, ozone concentrations accumulated to levels likely not possible without the smoke.

The analyses conducted provide evidence supportive of smoke impacts on ozone concentrations at the Northbrook Water Plant monitor on June 18 and 19, 2020, and show that (1) a considerable amount of smoke was transported from wildfires in Arizona across the central and southern United States into the Lake Michigan region in the days leading up to June 18 and 19, 2020; (2) smoke aloft was transported to the surface on June 18 and 19, 2020; and (3) smoke impacted ground-level pollution measurements at the Northbrook Water Plant monitor on June 18 and 19, 2020.

These images and measurements show that the smoke was transported over many days' time to Illinois. Additionally, HYSPLIT trajectories show that the smoke was transported from these wildfires to the upper Midwest in the days prior to June 18, 2020. In visible imagery and in CO and AOD measurements from satellite, the movement of smoke from Arizona to the Lake Michigan region is clear. These data show that wildfire smoke was present over the Northbrook monitor on the days of the event, June 18 and 19, 2020. This is further corroborated by the NOAA HMS smoke and Ozone AQI overlays during the episode period which also demonstrate a clear upwind path of smoke impacts on ozone concentrations.

Additional analyses show that vertical mixing and downward transport of smoke aloft to the surface occurred over June 18 and 19, 2020. On June 18 and 19, 2020, CALIPSO aerosol data show that smoke was present in the Lake Michigan region at near surface levels. The low elevation of the smoke is additionally supported by meteorological evidence. Radiosonde mixing height measurements show that vertical mixing from the altitude at which the smoke was present occurred on both June 18 and 19, 2020. Evidence is strong that smoke aloft over Chicago was mixed downward to the surface during this episode.

The arrival of smoke at the surface on June 18 and 19, 2020, impacted air quality in Chicago. Exceptionally high area-wide ozone concentrations were observed on that day. In addition, supporting measurements of PM2.5, CO, and NOx concentrations and speciated PM2.5 compounds of potassium ions and elemental carbon clearly indicate the presence of smoke. The exceedances at the Northbrook monitoring site represent the only regulatory significant observations in the NAA. Together, these analyses demonstrate that ozone concentrations at the Northbrook monitoring site were impacted on June 18 and 19, 2020, by wildfire smoke transported from fires in Arizona.

The comparisons and analyses provided within this document support Illinois' conclusion that the wildfire event affected air quality in such a way that there exists a clear causal relationship between the specific event and the monitored exceedances specified in Table 1, and thus satisfy the clear causal relationship criterion.

E. Not reasonably Controllable or Preventable

The Bush, Bighorn, and Mangum Arizona wildfires were not reasonably controllable and not reasonably preventable.

The Exceptional Events Rule presumes that wildfire events on wildland are not reasonably controllable or preventable [40 CFR §50.14(b)(4)]. Wildfire is defined in 40 CFR §50.1(n) as "any fire started by an unplanned ignition caused by lightning; volcanoes; other acts of nature; unauthorized activity; or accidental, human-caused actions, or a prescribed fire that has developed into a wildfire. A wildfire that predominantly occurs on wildland is a natural event." Wildland is defined in 40 CFR §50.1(o) as "an area in which human activity and development are essentially nonexistent, except for roads, railroads, power lines, and similar transportation facilities. Structures, if any, are widely scattered."

The exact cause of the Mangum fire remains under investigation; however, fire officials have confirmed it was human-caused and burned in the Kaibab National Forest of Arizona. The Bush Fire was a human-caused wildfire that started in the Tonto National Forest northeast of Phoenix, Arizona. Lightning has been identified as the cause of the Bighorn fire in the Santa Catalina Mountains north of Tucson, Arizona. Each of these wildfires predominantly occurred on wildland.

There is no evidence clearly demonstrating that prevention or control efforts beyond those made would have been reasonable. Therefore, emissions from these wildfires were not reasonably controllable or preventable.

F. A Natural Event

The June-July 2020 Bush, Bighorn, and Mangum wildfires were natural events. The definition of "wildfire" at 40 CFR §50.1(n) states, "A wildfire that predominantly occurs on wildland is a natural event." The events qualify as wildfires because either lightning or unplanned ignition likely due to human activities caused the unplanned wildfire events. The EPA generally considers the emissions of precursors from wildfires on wildland to meet the regulatory definition of a natural event at 40 CFR 50.1(k), defined as one "in which human activity plays little or no direct causal role." These wildfire events occurred on wildland, and accordingly, it has been shown that the events are natural events and may be considered for treatment as exceptional events.

G. Notification and Mitigation Requirements

Public Notification of the Event

The Exceptional Events Rule [40 CFR 50.14(c)(1)(i)] requires air agencies to "notify the public promptly whenever an event occurs or is reasonably anticipated to occur which may result in the exceedance of an applicable air quality standard." Illinois EPA posts daily air quality forecasts available at: http://airnow.gov/ and submits information to the National Weather Service when an Air Pollution Action Day is called.

Initial Notification of Potential Exceptional Event

The Exceptional Events Rule [40 CFR 50.14(c)(2)(i)] requires air agencies to notify U.S. EPA of its intent to request exclusion data due to an exceptional event by creating an initial event description and flagging the associated data in the AQS database. Illinois EPA tendered the requisite notice verbally and later in writing, and flagged the June 18 and 19, 2020, data in the AQS database.

Mitigation Plan

The Exceptional Events Rule [40 CFR 51.930(b)] requires states having areas with historically documented or known seasonal events to develop and submit a mitigation plan. According to the Rule, historically documented or known seasonal events include events of the same type and pollutant that recur in a three-year period and involve three events or event seasons for which a State submits an Exceptional Event Demonstration or which are the subject of an initial notification for a potential exceptional event. In such cases, U.S. EPA would notify the State that it is subject to the Mitigation Plan requirements. Illinois does not have historically documented or known seasonal events and U.S. EPA has not notified the State that it is subject to these requirements. As such, Illinois is not required to develop and submit a mitigation plan.

Summary

This Exceptional Event demonstration shows that the Bush, Bighorn, and Mangum wildfires in Arizona adversely affected ozone data in a regulatory significant way, such that ozone data on June 18 and 19, 2020, for the Northbrook Water Plant monitor identified in Table 1 meet the rules as an Exceptional Event and should be excluded from regulatory determinations.

This report:

1. Contains the required narrative conceptual model describing the Arizona wildfire events that caused the violation at the Northbrook ozone monitor, and how emissions from those events reached the affected monitor, leading to elevated measured ozone concentrations on the specific days in question.
2. Demonstrates that there was a clear causal relationship between the smoke and the MDA8 ozone exceedances.
3. Contains analyses comparing the ozone concentrations during the event-influenced days to concentrations at the same monitor at other times on days with similar meteorological conditions.
4. Demonstrates that the wildfires causing smoke were not reasonably controllable or preventable and are unlikely to recur, and that they were considered natural events.

Key findings and evidence supporting these assertions include the following:

1. Considerable ozone was created upstream of Illinois due to the presence of wildfire smoke generated during one of Arizona's largest recorded wildfire years, which was then transported into Illinois over several days.
2. Meteorological conditions (at the surface and aloft) were favorable for transport of smoke from the southwestern U.S. into the Lake Michigan region, including Illinois.
3. Ozone concentrations on June 18 and 19, 2020, at the Northbrook monitor were above the 99th percentile of the 5-year distribution of ozone monitoring data at the site and were both in the four highest ozone concentrations within the year and were the 9th and 11th highest observations in the past 5-year period.
4. Satellite images captured visual smoke plumes that were transported into the Lake Michigan region on days when the ozone concentrations were highest.
5. Analysis of the NOAA HMS smoke product and Ozone AQI shows an enhanced ozone concentration impact at monitors along the wildfire smoke transport path that eventually culminates with excess ozone observations in Chicago.
6. CALIPSO retrievals identified smoke among the classified aerosols at the surface in the region during the June 18 and 19, 2020, episode.
7. Regional upwind measurements identify multiple monitors with unusually high ozone concentrations during the dates when the transported smoke plume passes through the region.
8. HYSPLIT model forward and backward trajectory analyses demonstrate that the wildfire smoke was transported into the Lake Michigan region and was then transported into the Chicago area.
9. Additional satellite retrievals demonstrate the transport of wildfire smoke into the Lake Michigan region and provide additional evidence that the smoke plume and associated ozone precursor emissions were present during the June 18 and 19, 2020, episode.
10. PM2.5, CO, and NOx were elevated during the event, consistent with a wildfire smoke plume.
11. PM2.5 speciated data (OC and K+) showed elevated wildfire attributable concentrations.

12. Similar day analysis showed similar days in previous years did not yield as much ozone.
13. A screening analysis of average standardized log-transformed timeseries concentrations of key pollutants provides supporting evidence for smoke influence in the Chicago region during the June 18-19, 2020, episode.
14. A Q/d analysis, while not meeting specific U.S. EPA thresholds for clear causal influence, is consistent with other previous long-range smoke and ozone transport events approved by U.S. EPA.

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Appendix A - 700 mb Pressure Patterns with Winds for June 16-20, 2020

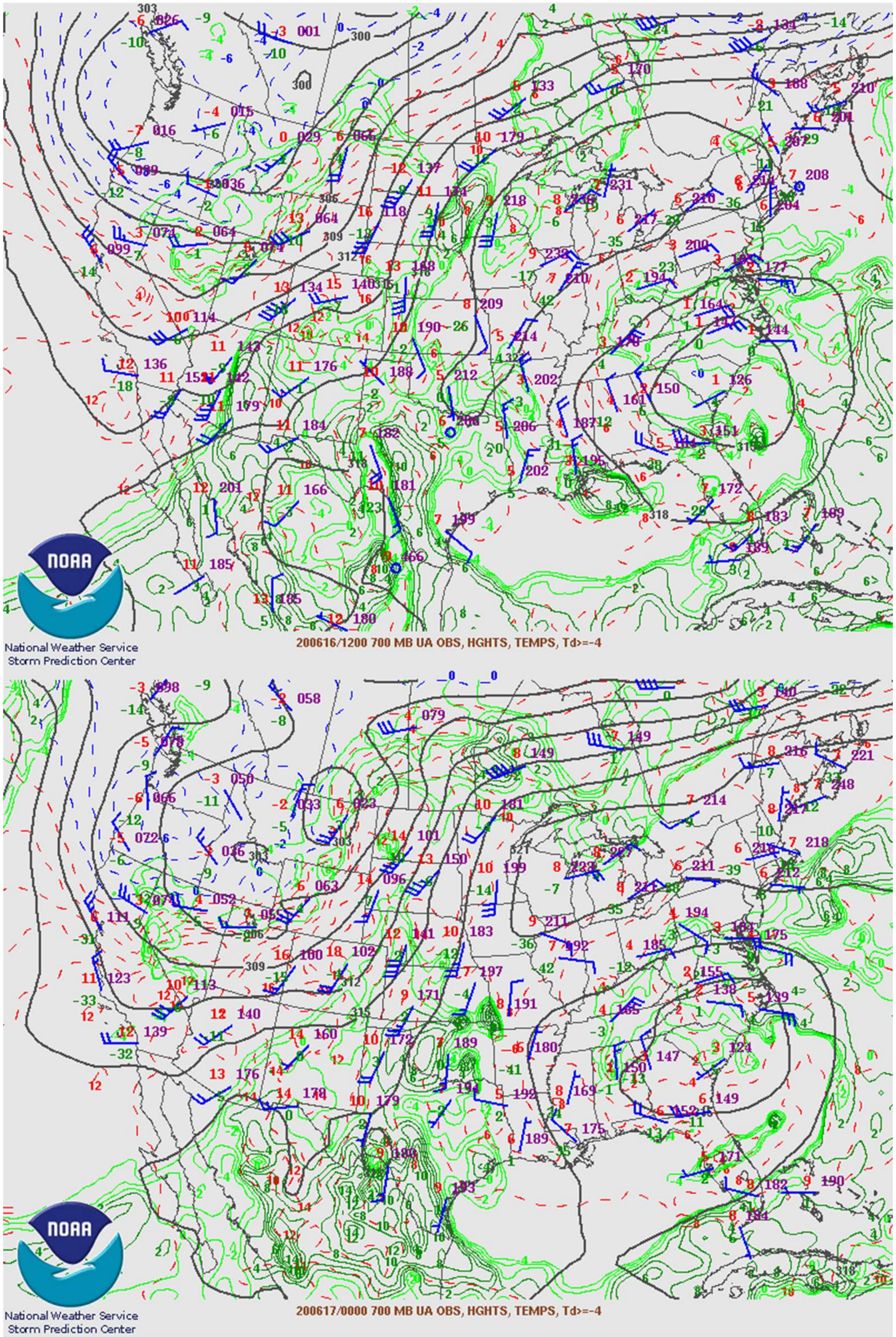


Figure A-1. 700 mb Pressure Patterns with Winds for June 16, 2020, (7 am CDT top; 7 pm bottom)

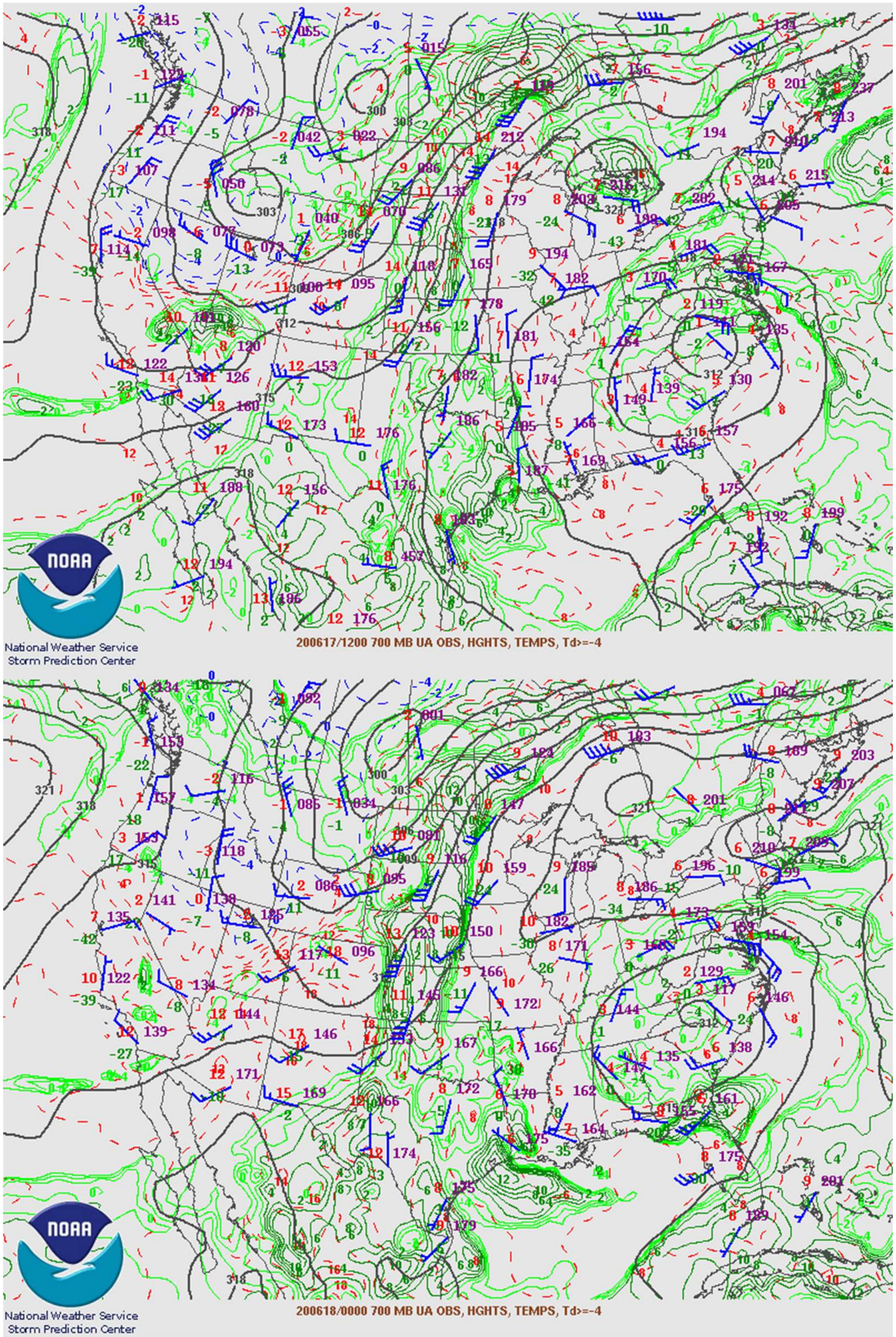


Figure 63. 700 mb Pressure Patterns with Winds for June 17, 2020, (7 am CDT top; 7 pm bottom)

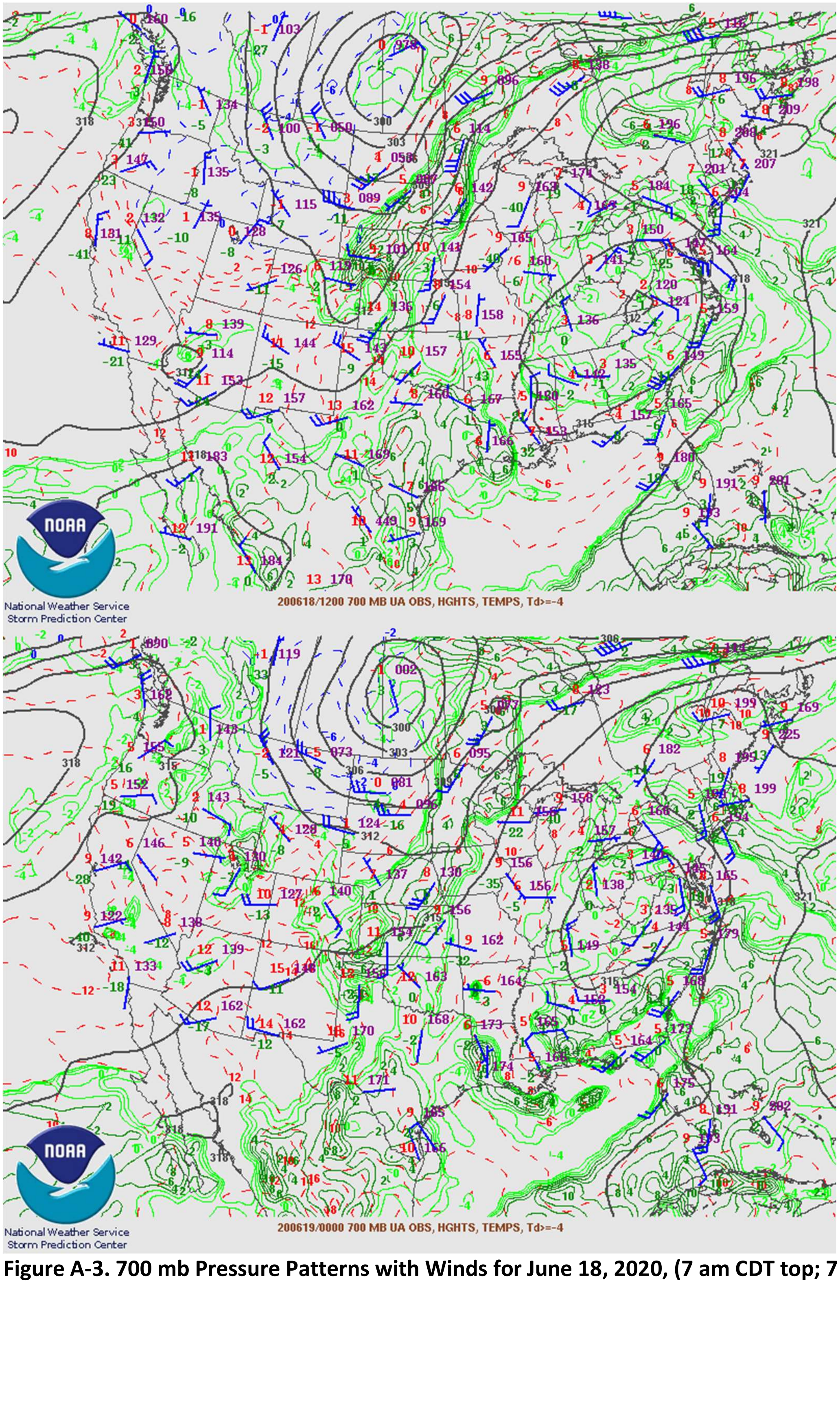


Figure A-3. 700 mb Pressure Patterns with Winds for June 18, 2020, (7 am CDT top; 7 pm bottom)

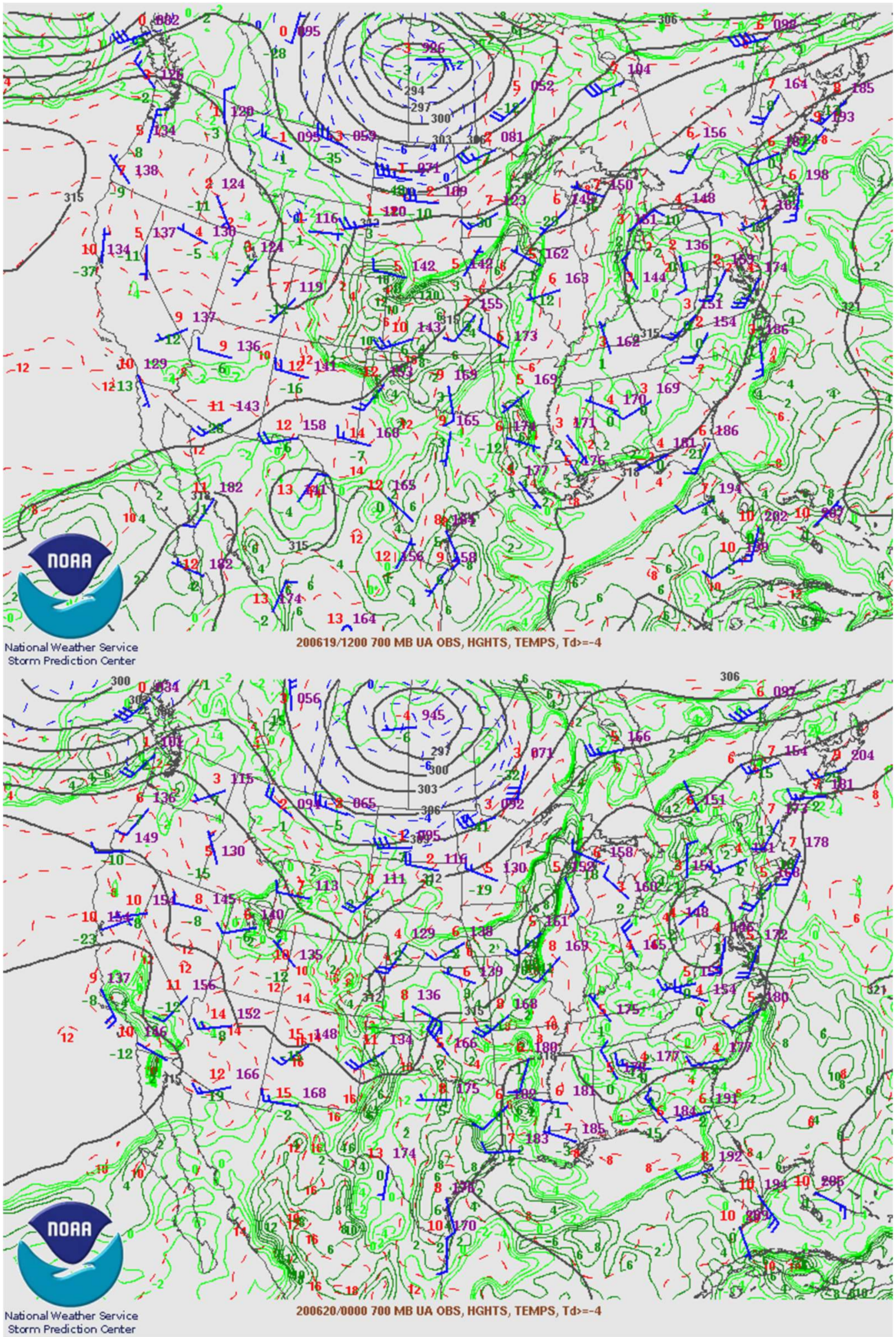


Figure A-4. 700 mb Pressure Patterns with Winds for June 19, 2020, (7 am CDT top; 7 pm bottom)

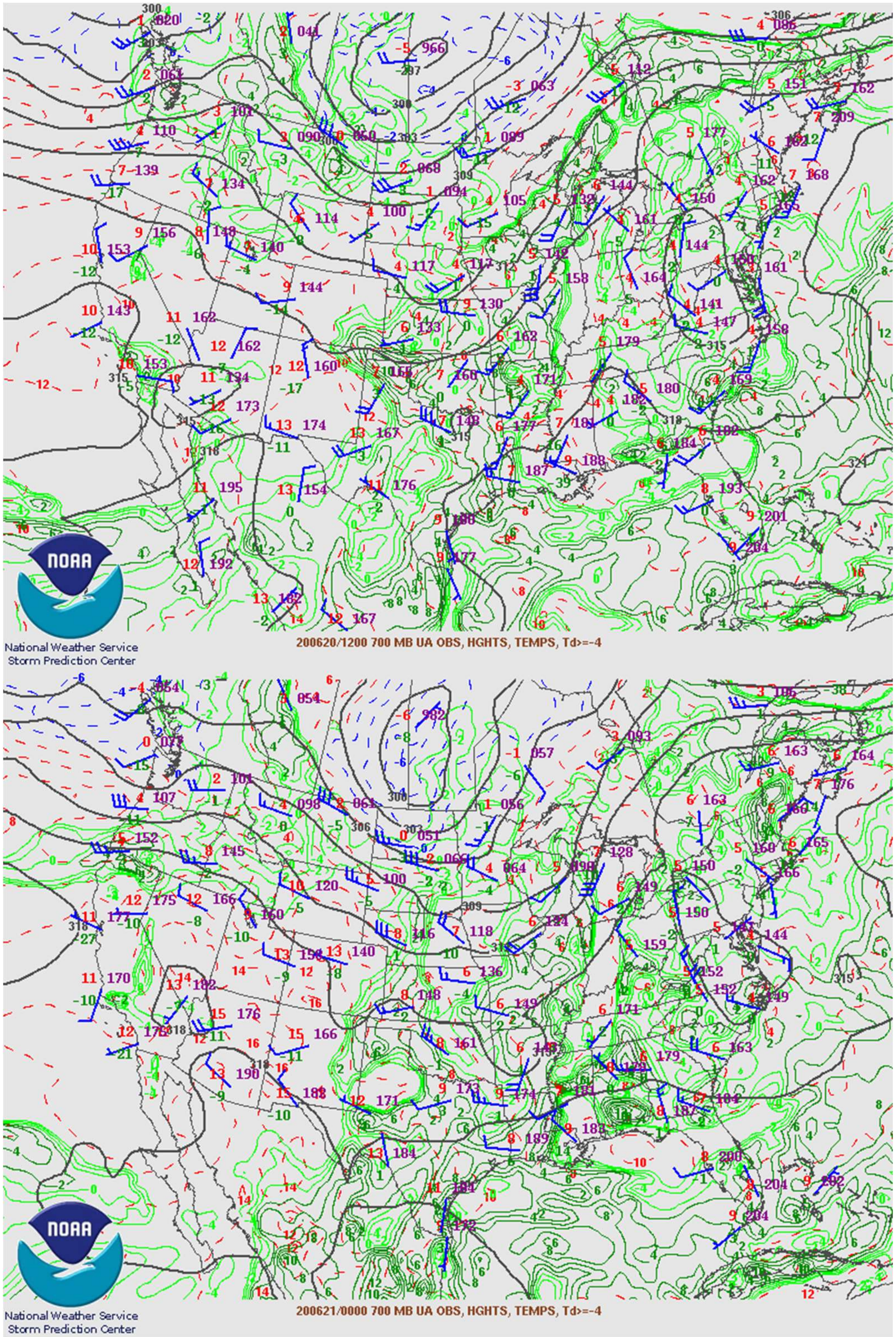


Figure A-5. 700 mb Pressure Patterns with Winds for June 20, 2020, (7 am CDT top; 7 pm bottom)

Appendix B - 850 mb Pressure Patterns with Winds for June 16-20, 2020

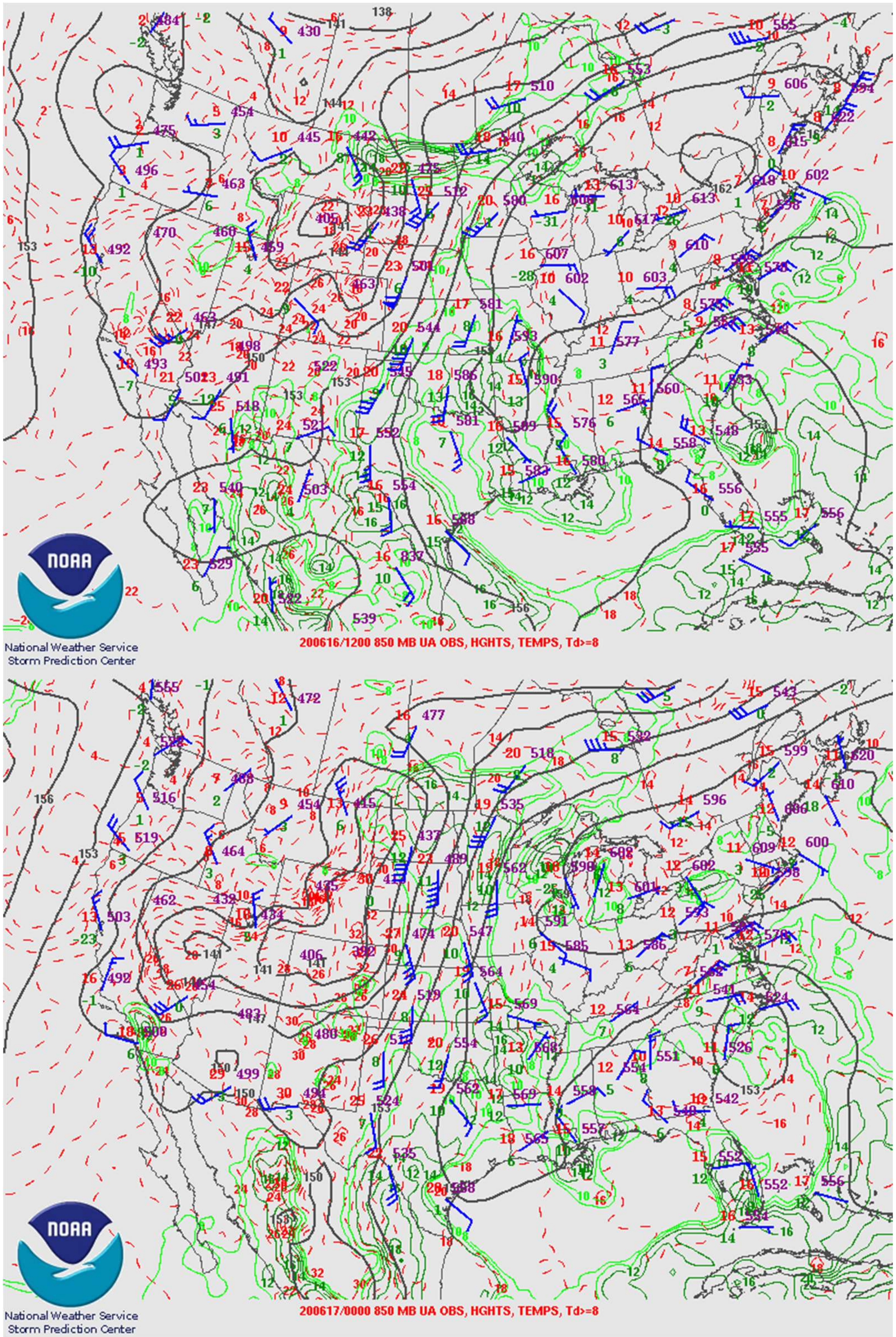


Figure B-1. 850 mb Pressure Patterns with Winds for June 16, 2020, (7 am CDT top; 7 pm bottom)

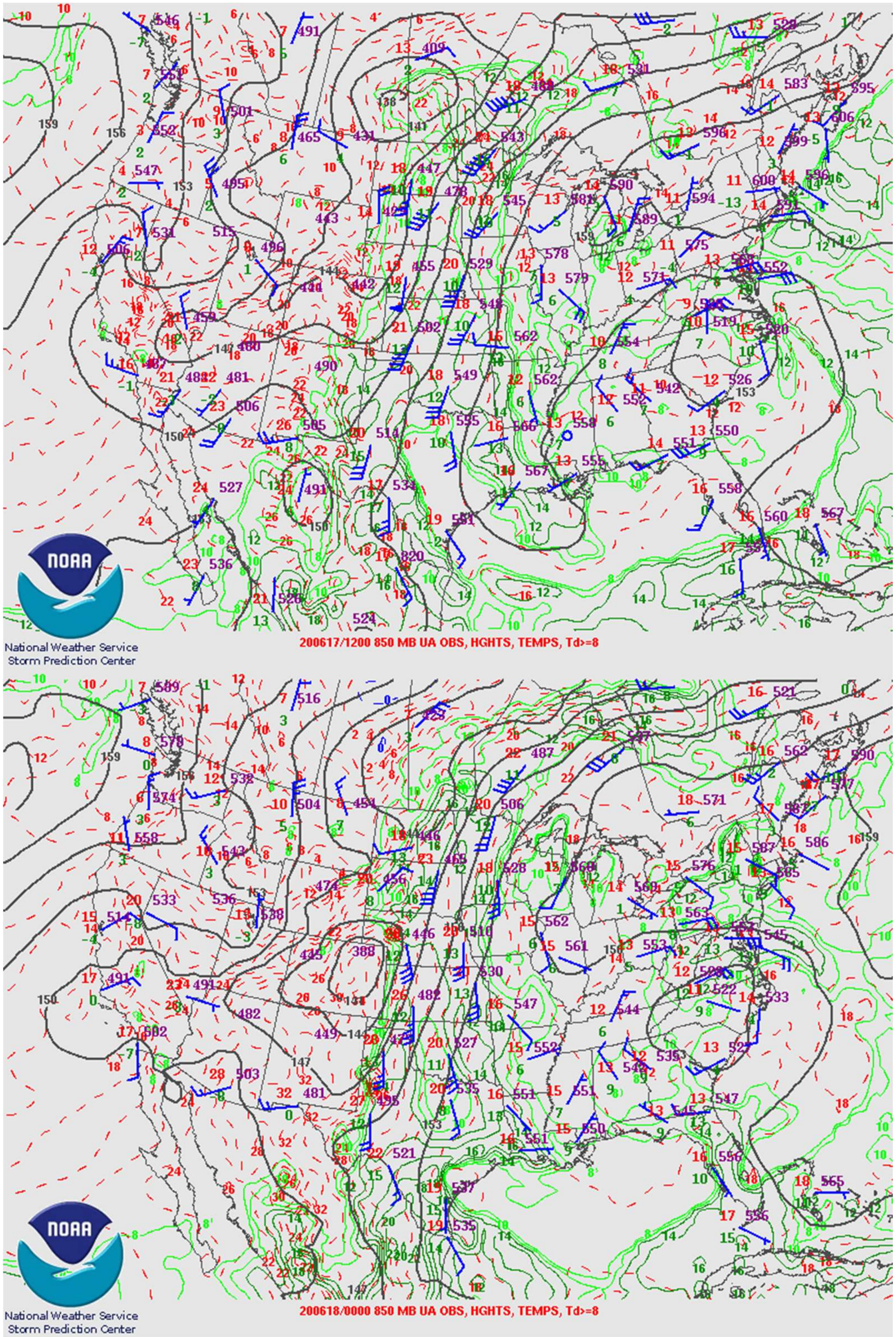
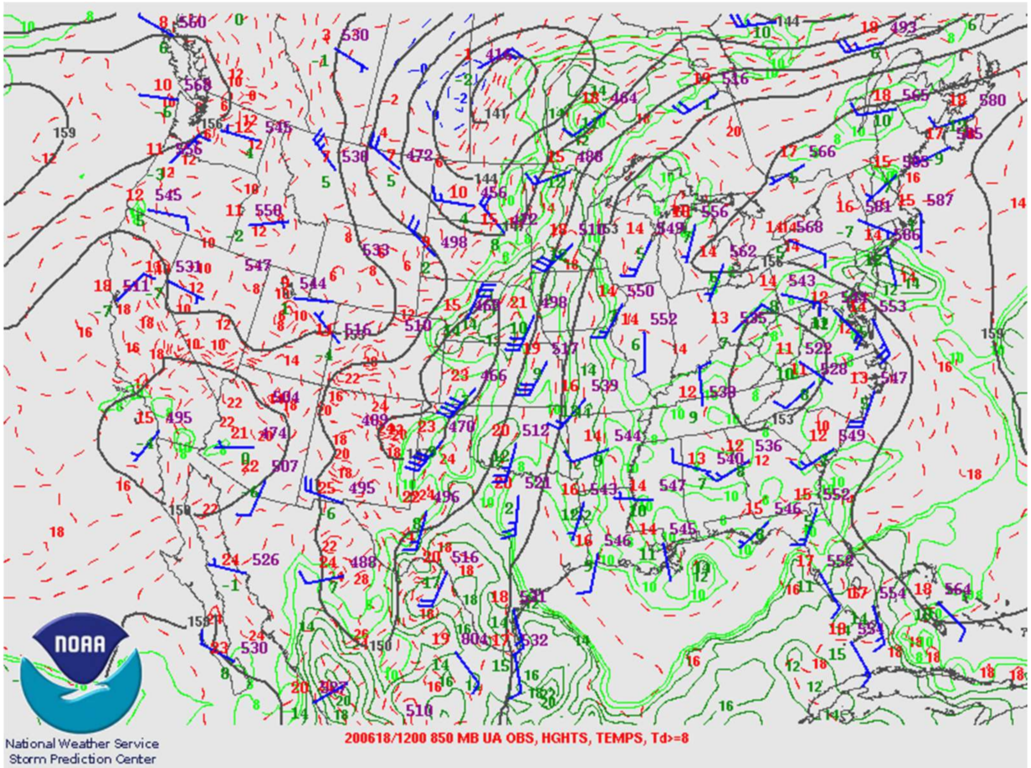


Figure B-2. 850 mb Pressure Patterns with Winds for June 17, 2020, (7 am CDT top; 7 pm bottom)



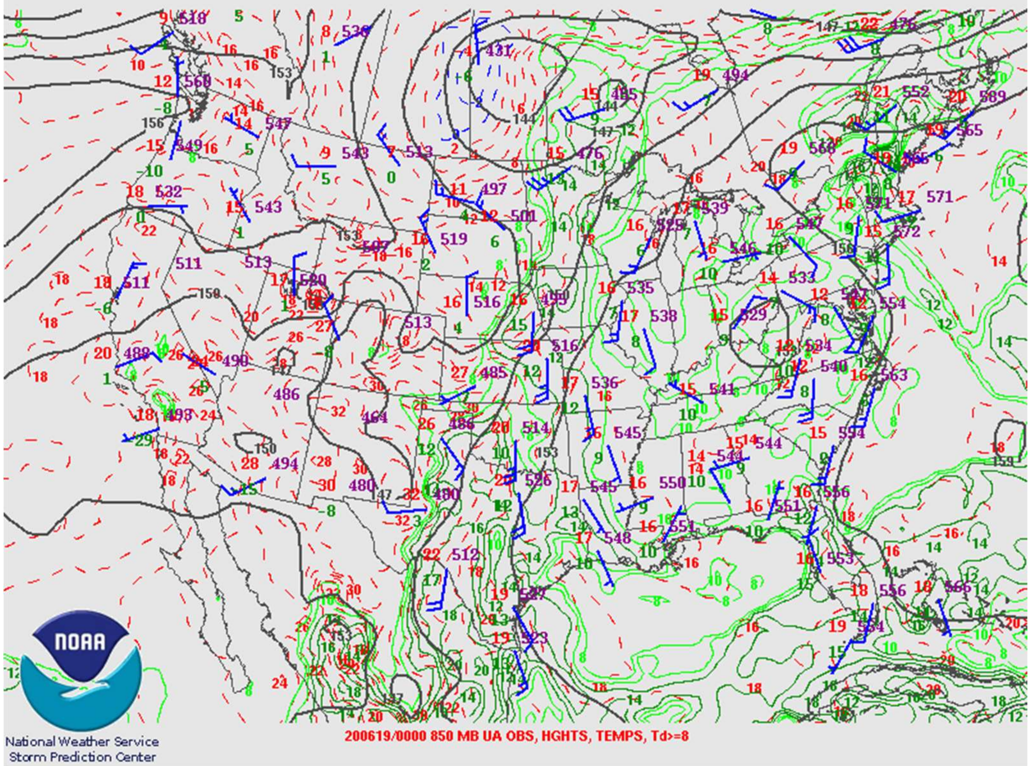


Figure B-3. 850 mb Pressure Patterns with Winds for June 18, 2020, (7 am CDT top; 7 pm bottom)

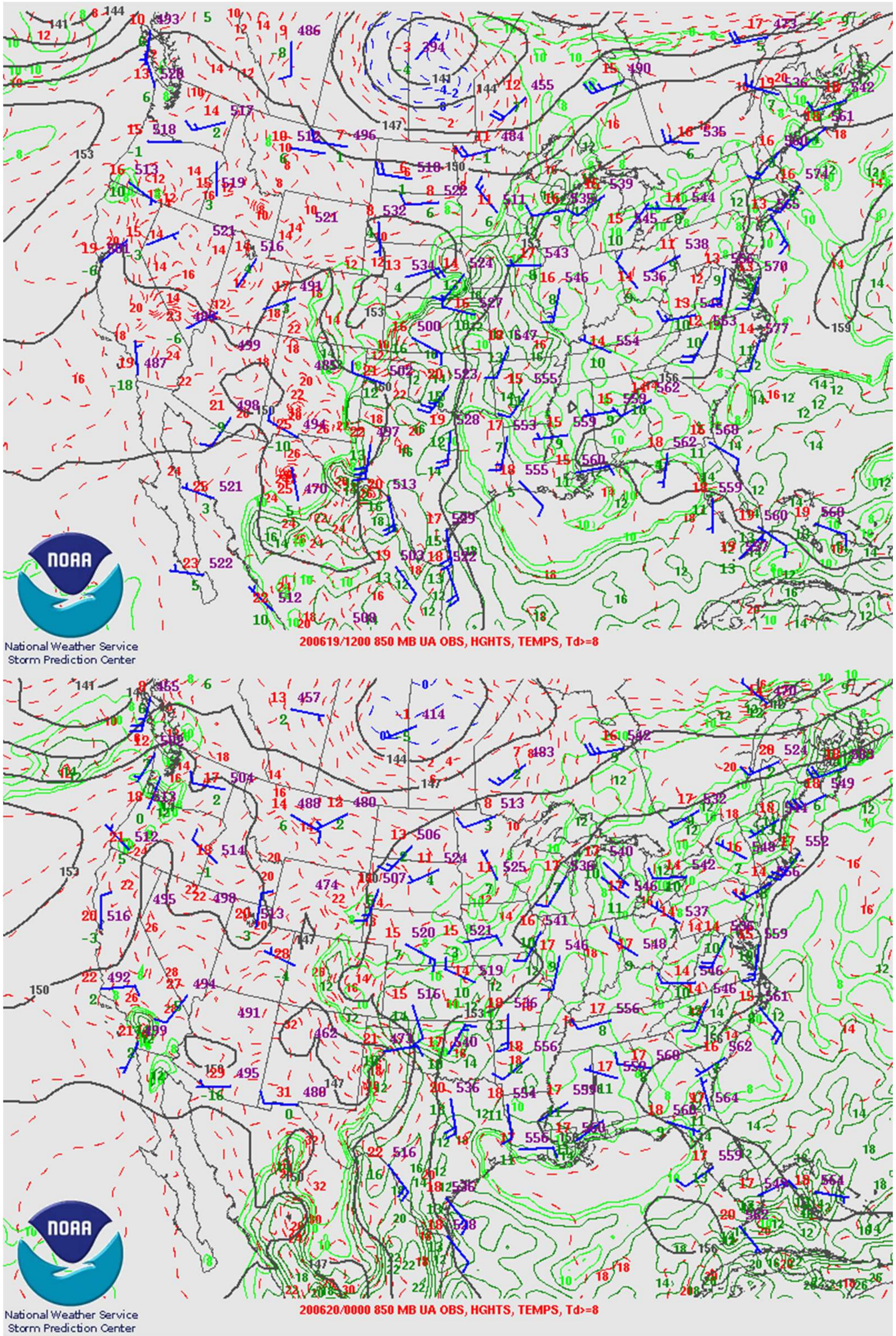


Figure B-4. 850 mb Pressure Patterns with Winds for June 19, 2020, (7 am CDT top; 7 pm bottom)

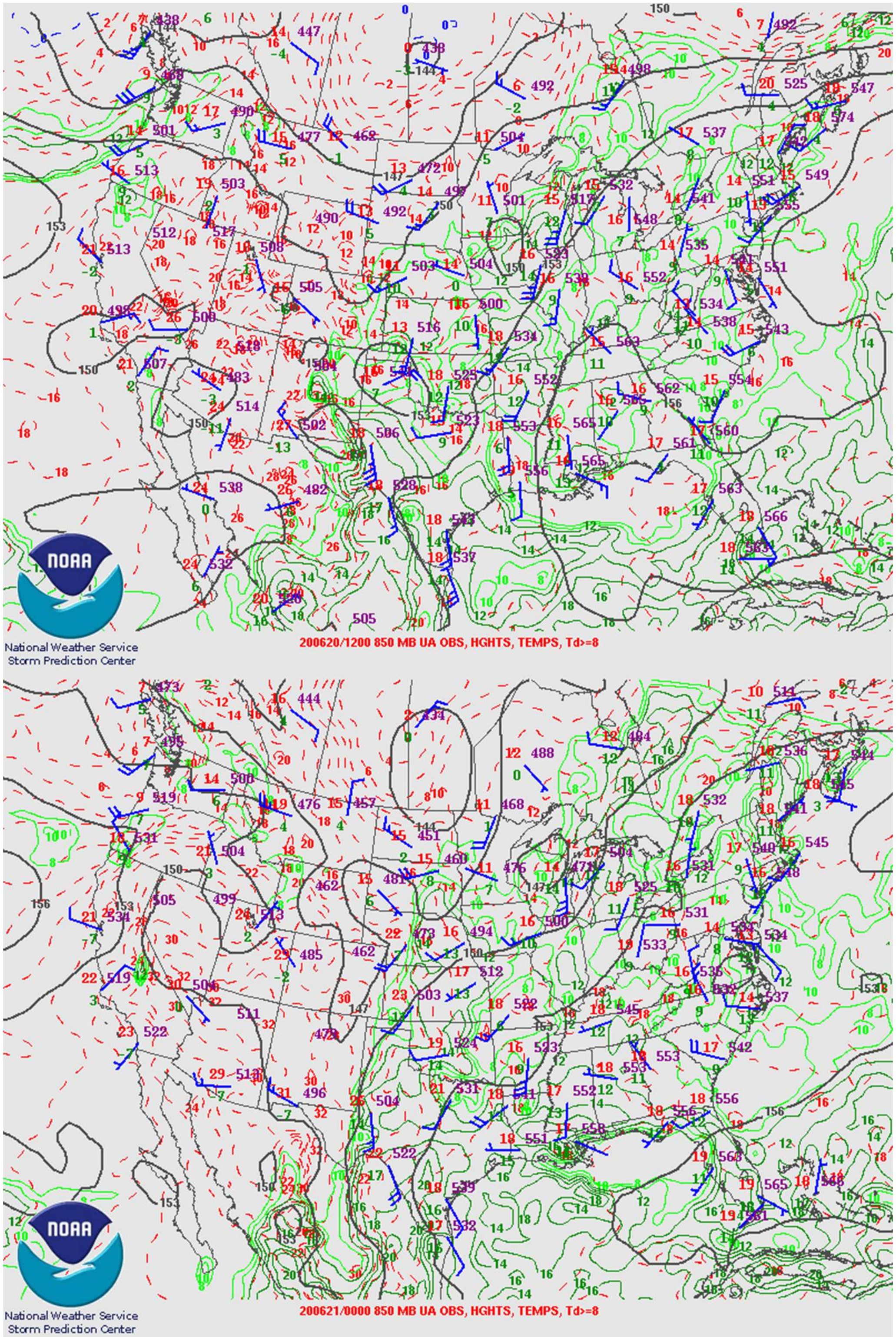


Figure B-5. 850 mb Pressure Patterns with Winds for June 20, 2020, (7 am CDT top; 7 pm bottom)

Appendix C - Surface Pressure Patterns with Winds for June 16-20, 2020

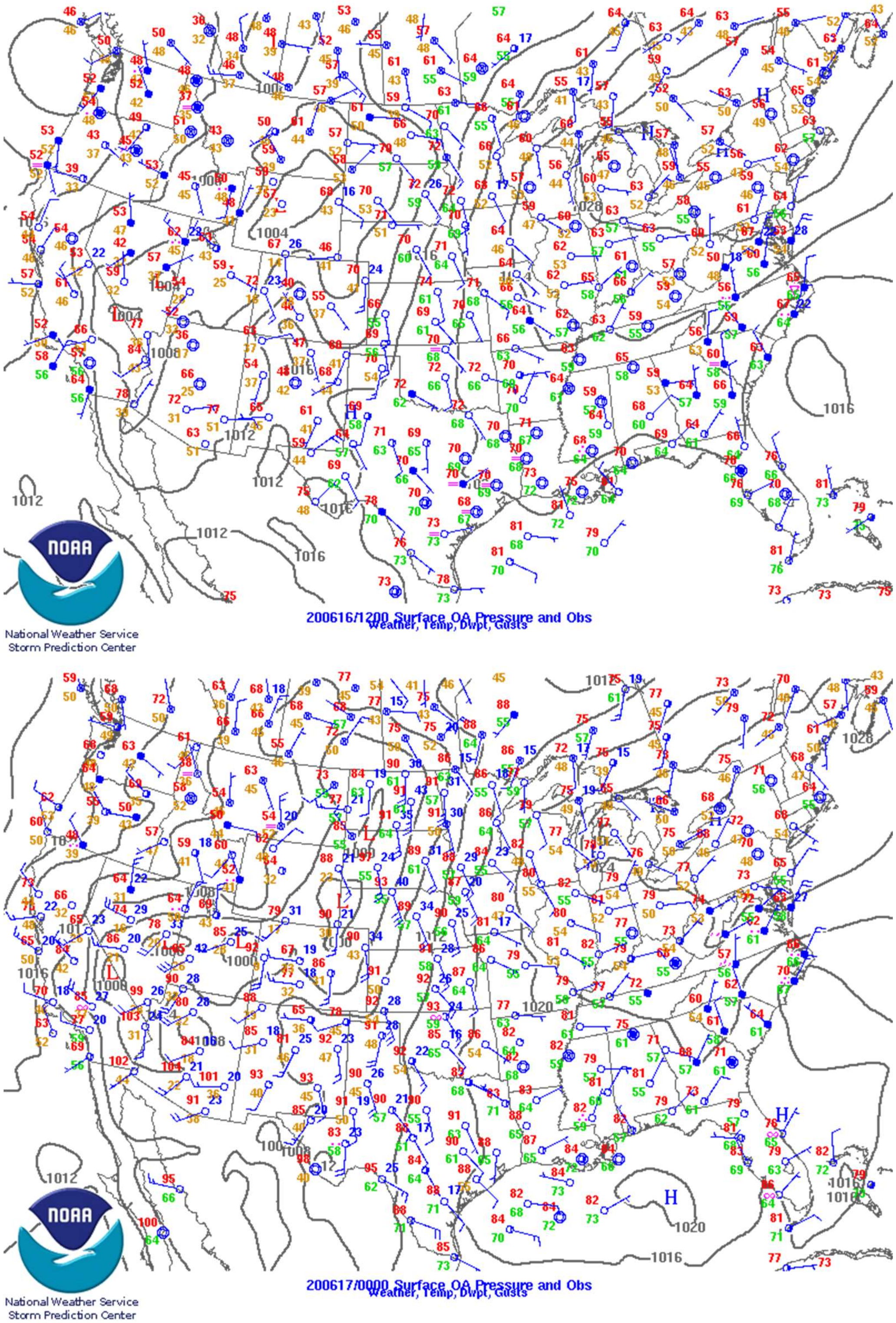


Figure C-1. Surface Pressure Patterns with Winds for June 16, 2020, (7 am CDT top; 7 pm bottom)

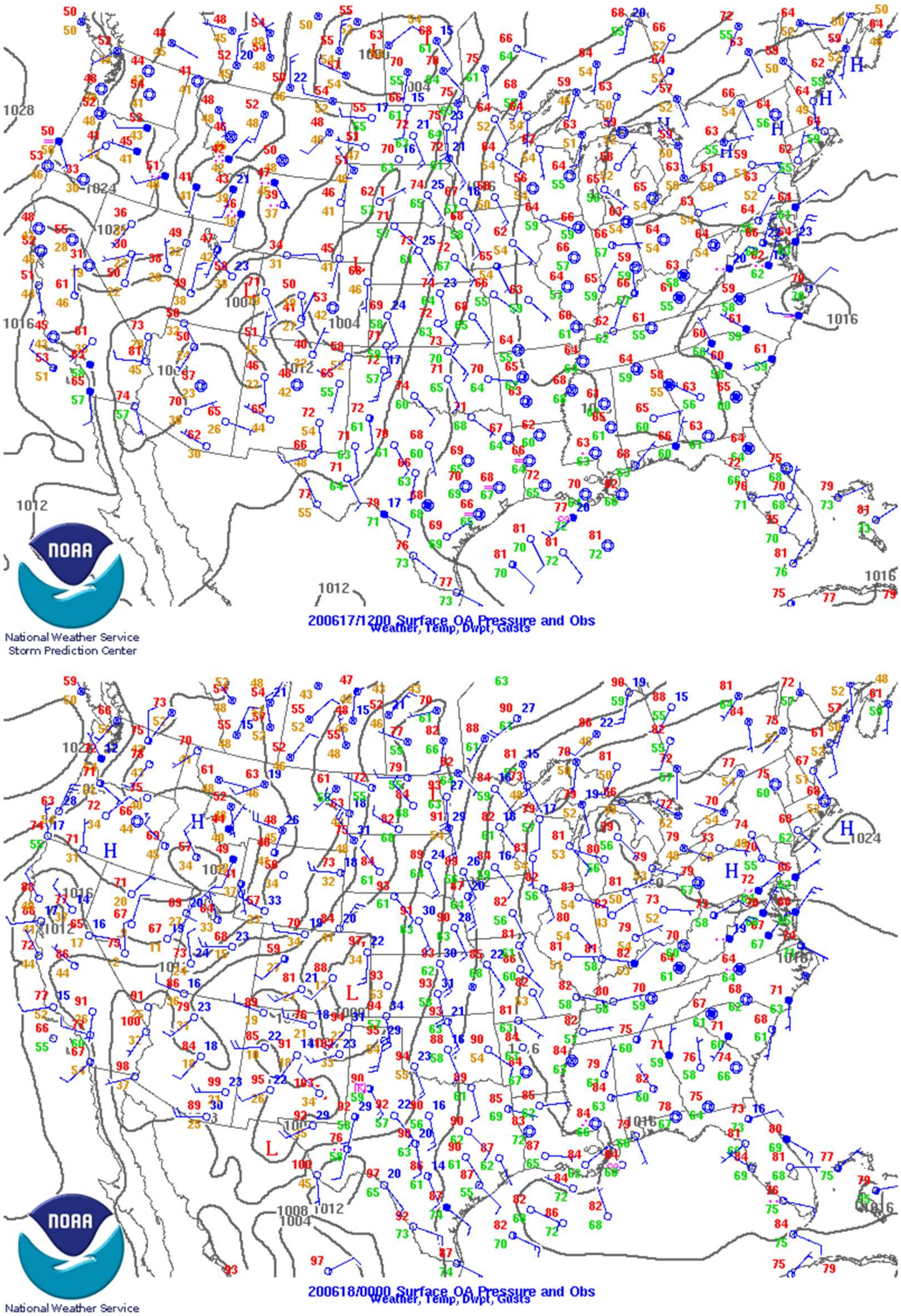
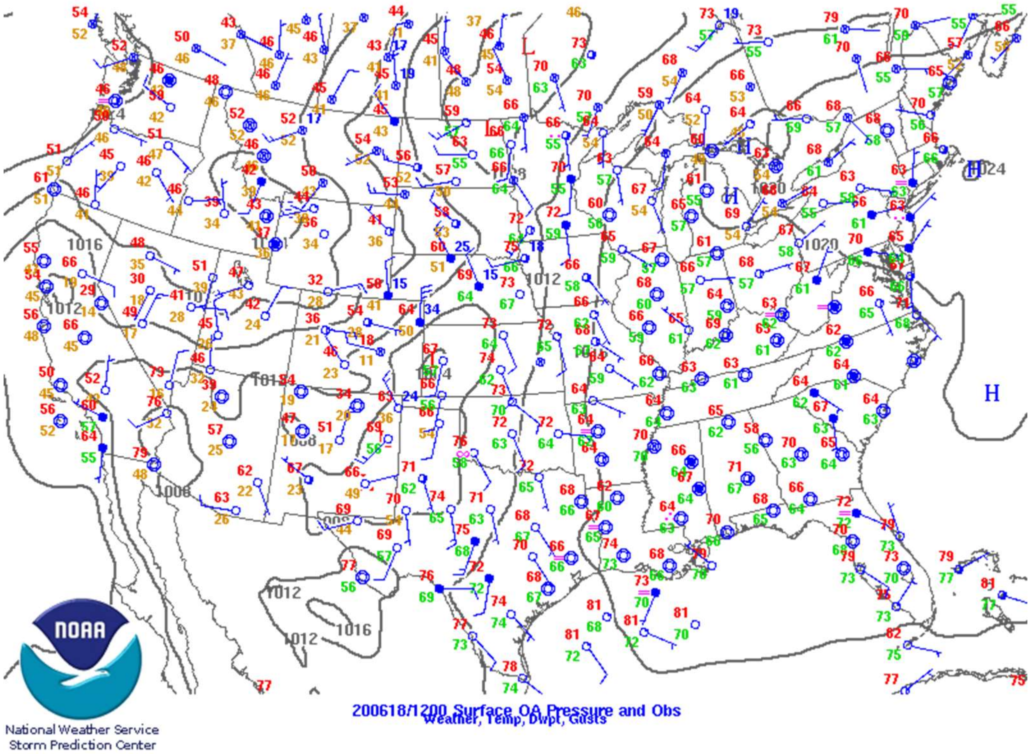


Figure C-2. Surface Pressure Patterns with Winds for June 17, 2020, (7 am CDT top; 7 pm bottom)



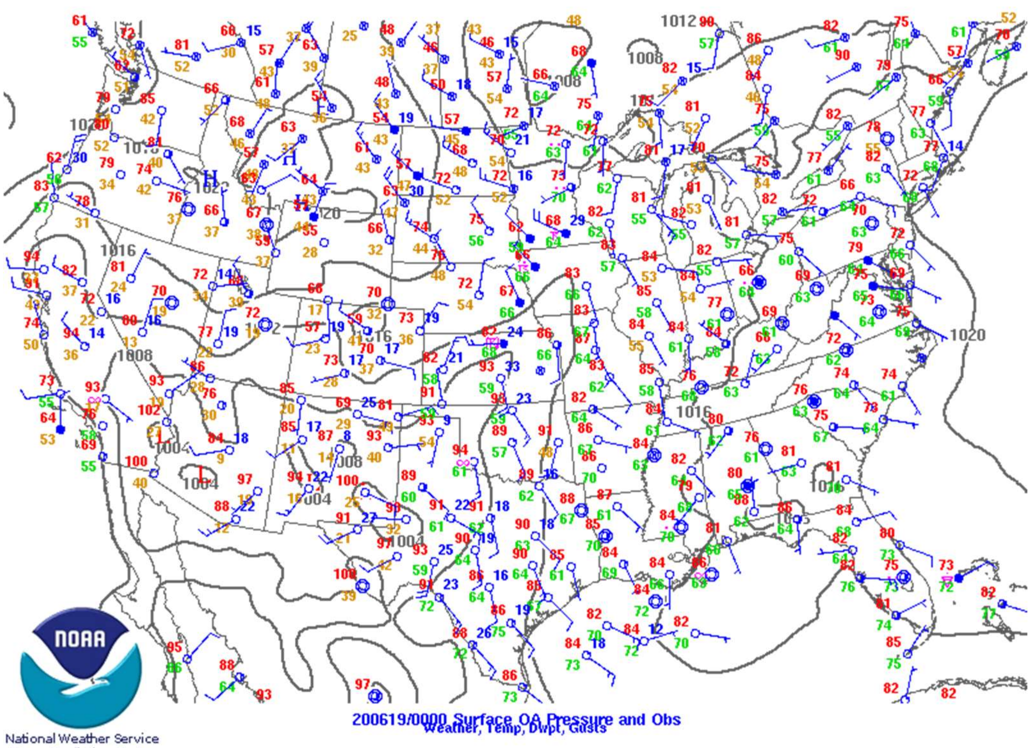
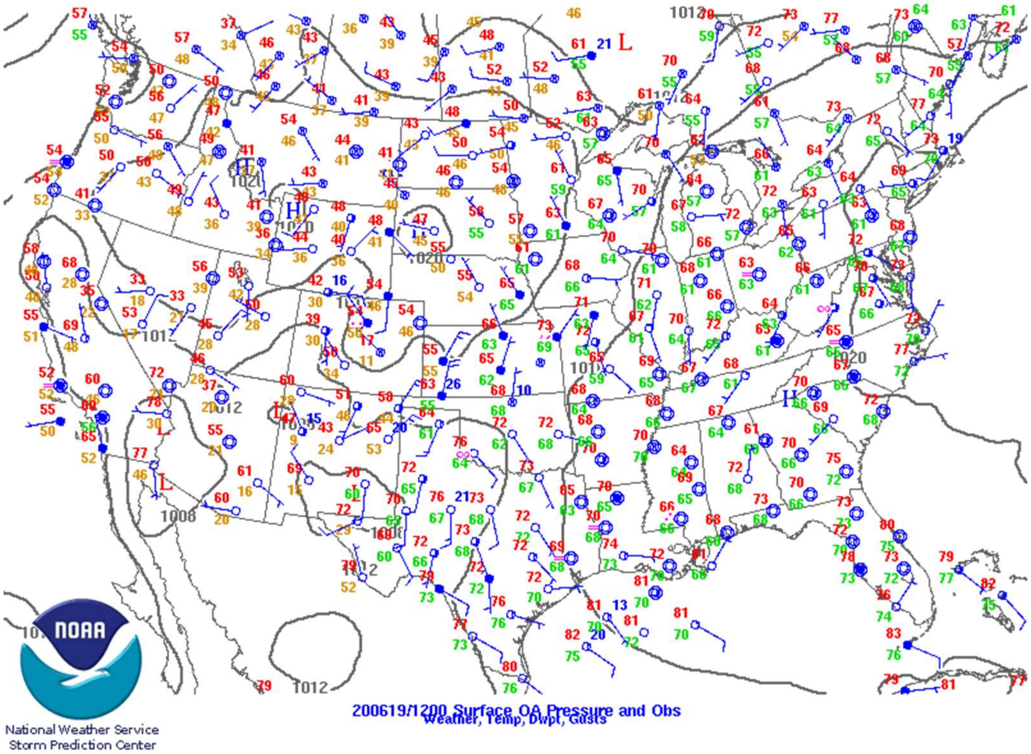


Figure C-3. Surface Pressure Patterns with Winds for June 18, 2020, (7 am CDT top; 7 pm bottom)



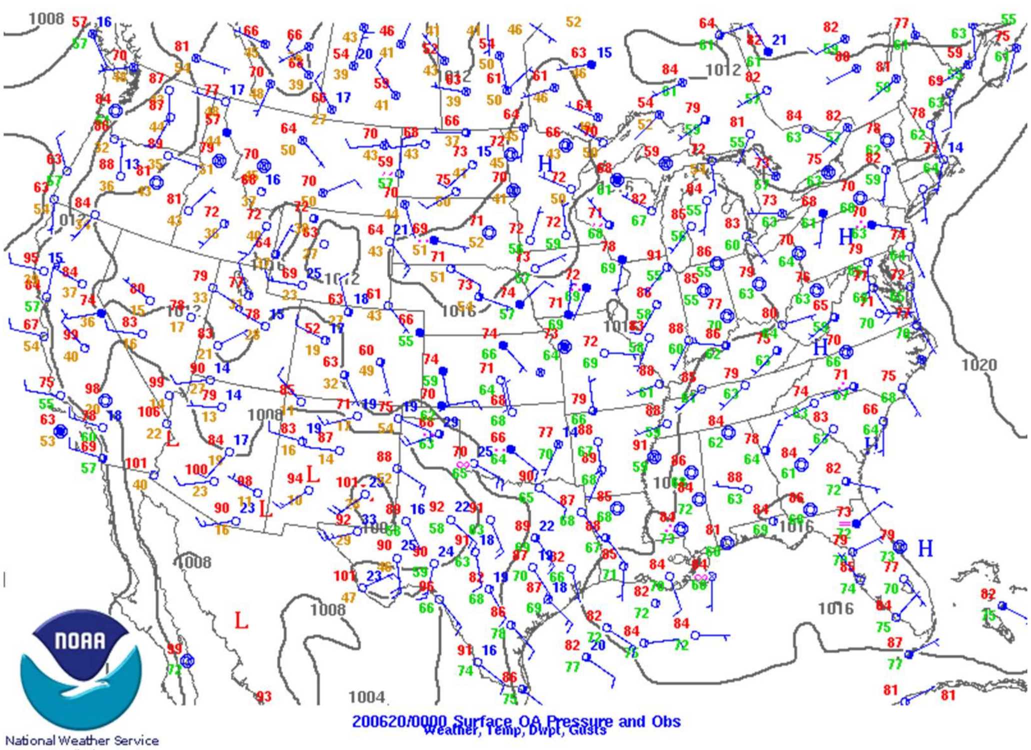
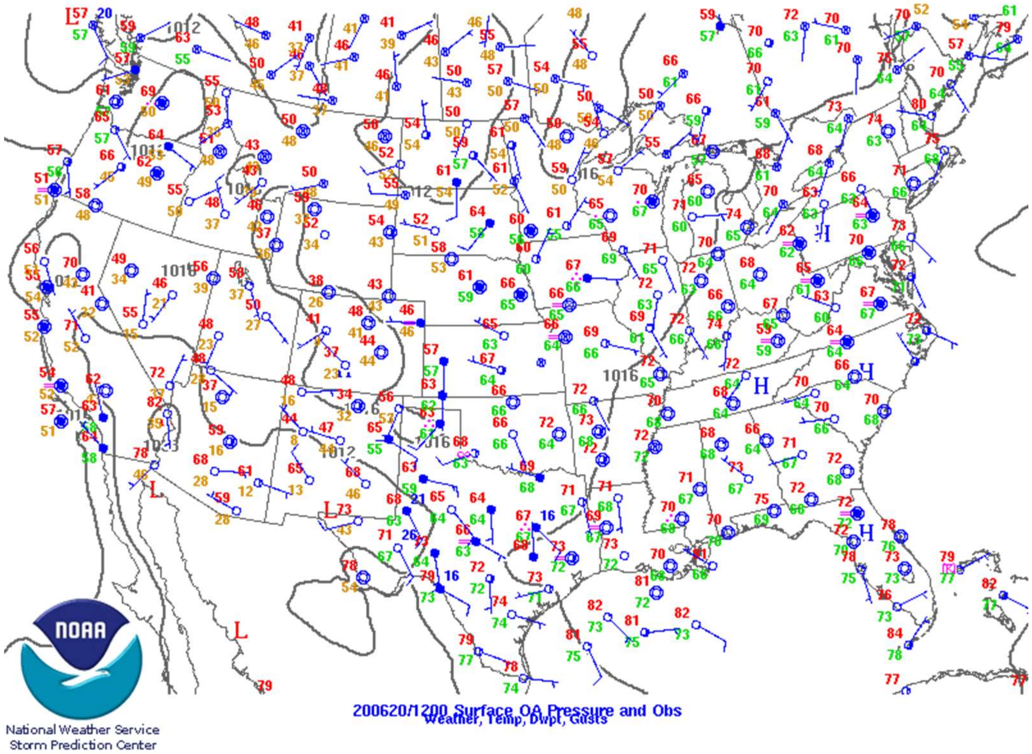


Figure C-4. Surface Pressure Patterns with Winds for June 19, 2020, (7 am CDT top; 7 pm bottom)



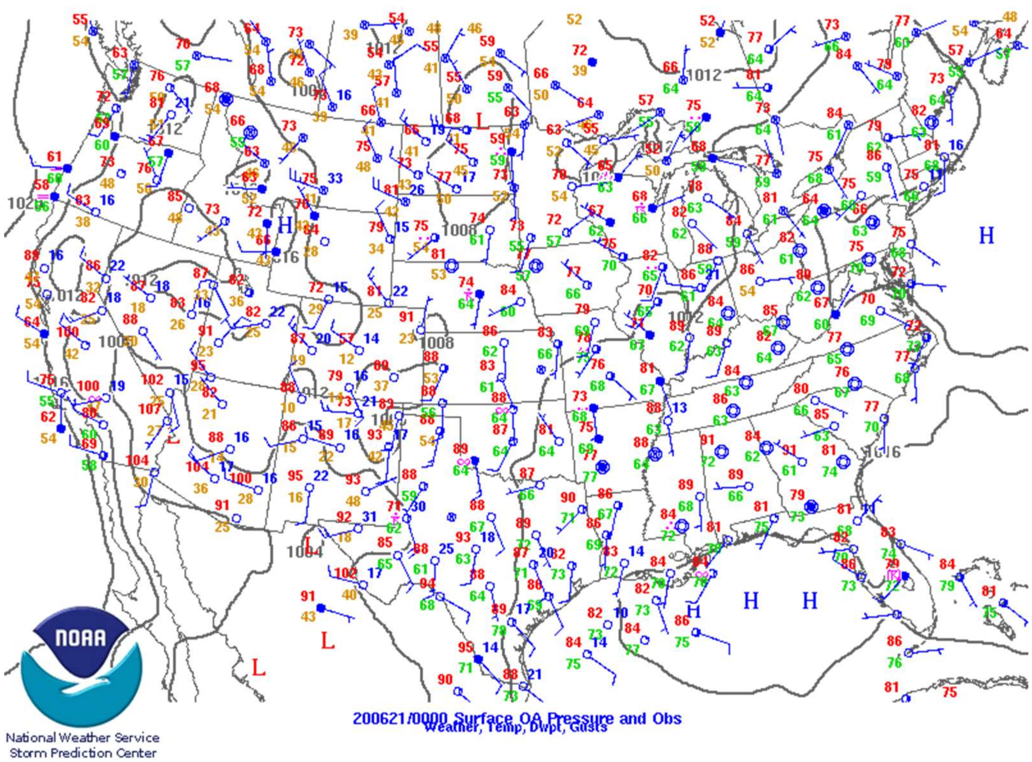


Figure C-5. Surface Pressure Patterns with Winds for June 20, 2020, 7 am CDT top; 7 pm bottom)

Appendix D - NAM12 Modeled Soundings for June 16-20, 2020, at KORD

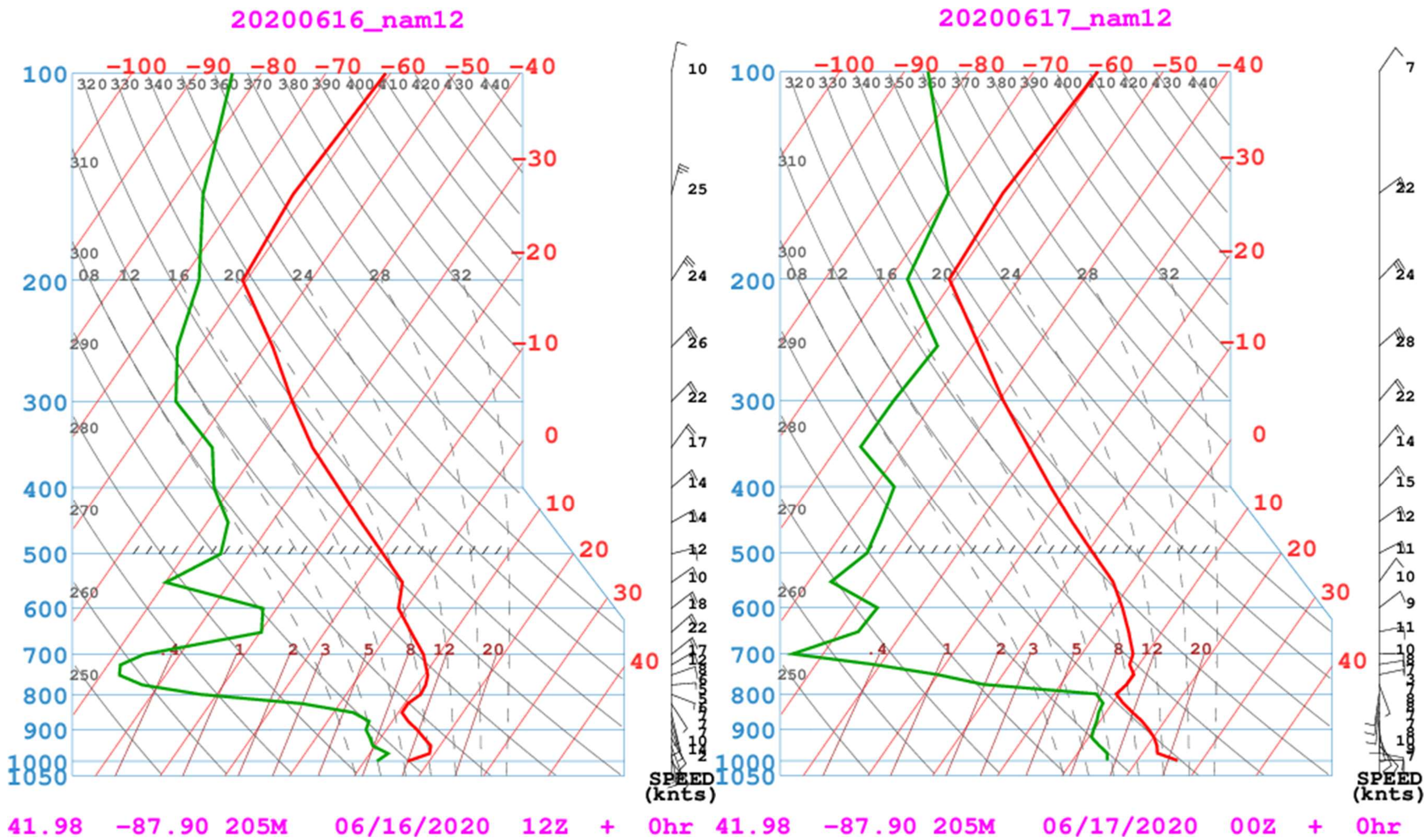


Figure D-1. Modeled Soundings for June 16, 2020, at KORD (7 am CDT left; 7 pm right)

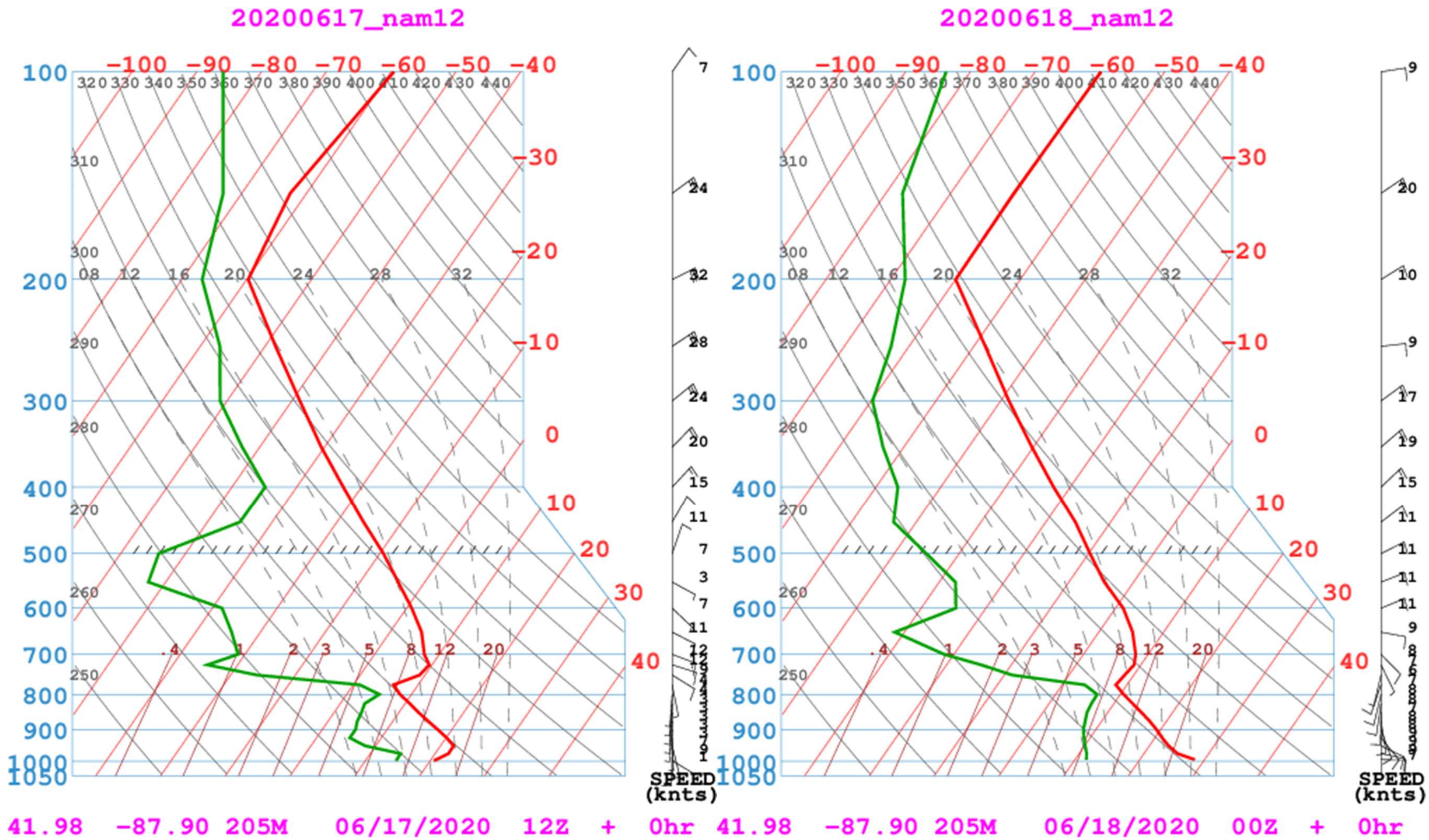


Figure D-2. Modeled Soundings for June 17, 2020, at KORD (7 am CDT left; 7 pm right)

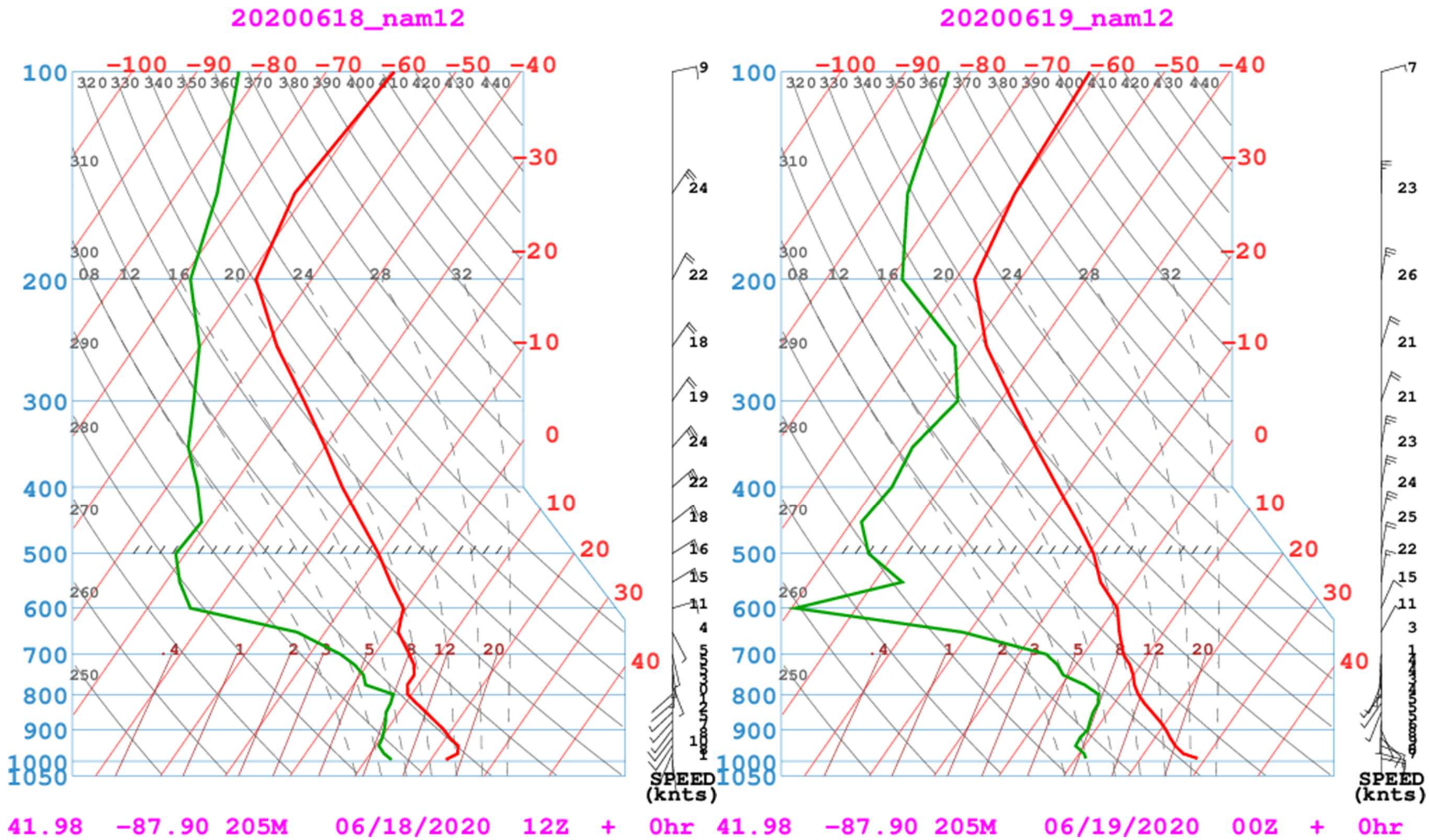


Figure D-3. Modeled Soundings for June 18, 2020, at KORD (7 am CDT left; 7 pm right)

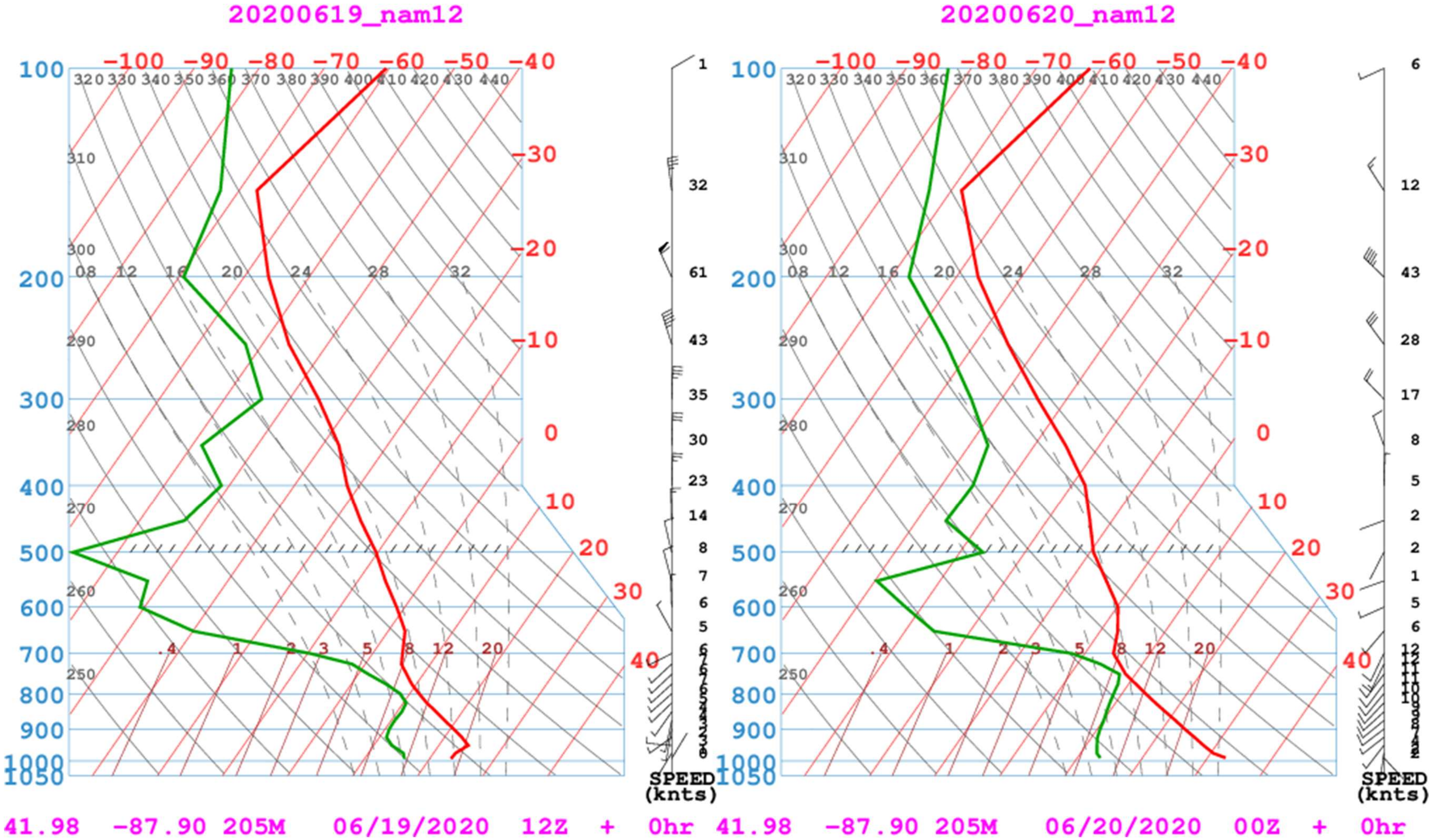


Figure D-4. Modeled Soundings for June 19, 2020, at KORD (7 am CDT left; 7 pm right)

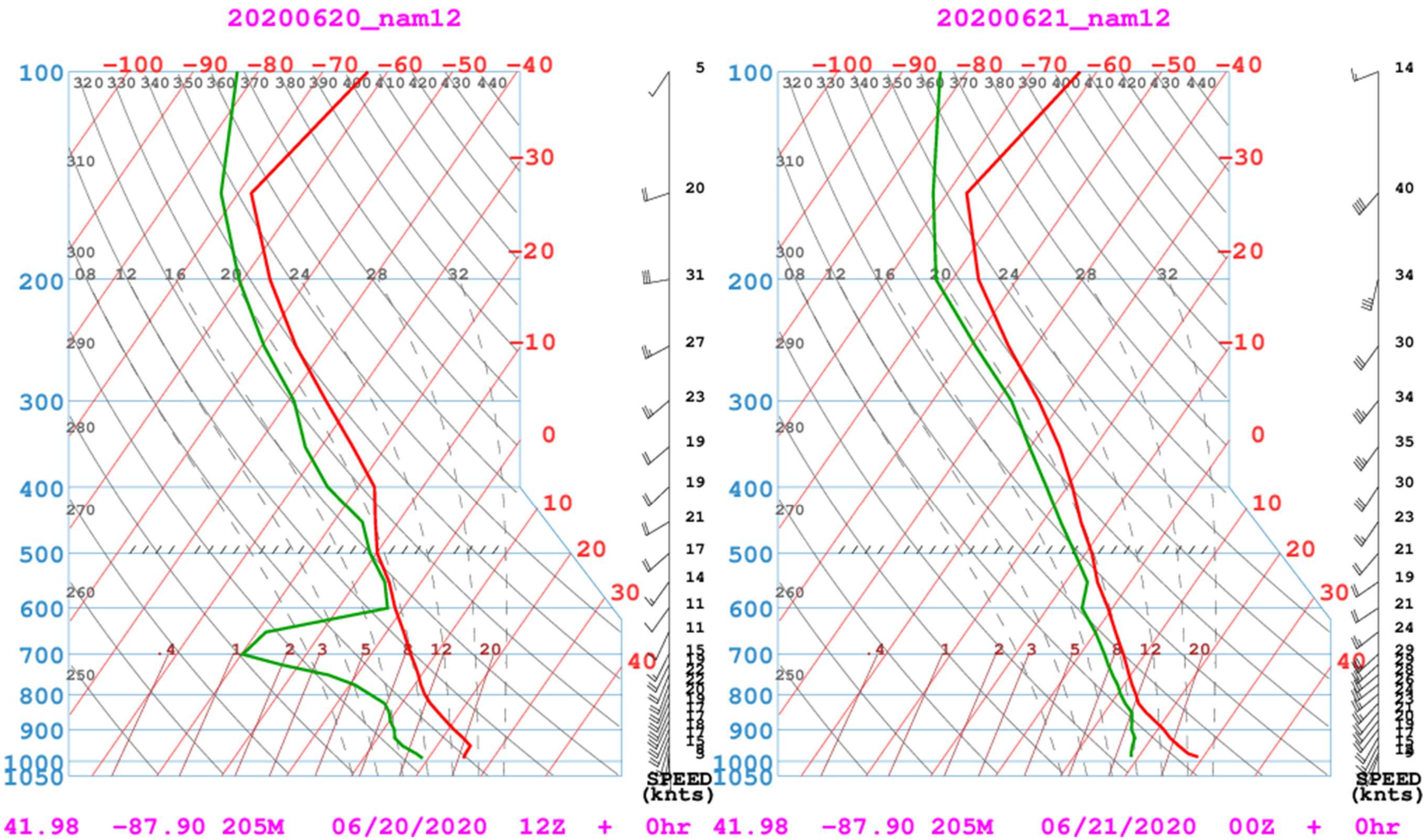


Figure D-5. Modeled Soundings for June 20, 2020, at KORD (7 am CDT left; 7 pm right)